The Dock & Harbour Authority

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The Dock and Harbour Authority

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Editorial Comments

New Volume.

With this number is commenced the second volume of the Journal in the reduced format, which had to be adopted under war-time restrictions twelve months ago. Evidently, it must remain the standard of production for some time longer. We are wondering how the reduction in page size has appealed to our readers and whether they have not found it a more convenient size for handling and perusal than the former crown folio size.

The question does not assume any urgency until the time arrives for freedom of choice, but it would be interesting and helpful to have the views of our readers in advance, if they would be so good as to communicate them to us. We are alluding, of course, to page dimensions, not to the number of pages, which, under the more favourable conditions after the war, will be restored to their former quota.

The Metropolitan Port of Eire.

As will be seen from the article in this issue, Dublin, the metropolitan port of Eire, has had a long and eventful history. We do not propose to expatiate further on it in this Comment, since Mr. Kane has admirably set out the record in full detail. We are rather minded to refer to a matter which is but briefly touched on in his article.

The port is of outstanding interest, not merely from an historical point of view; it has provided one of the most difficult and perplexing problems which can confront the harbour engineer who is set the task of securing safe and adequate access to a port from the high seas. Like a number of other rivers, the Liffey is impeded for navigation by the existence of a pronounced bar, in this case due to the large quantities of sand and detritus which have been brought into Dublin Bay by coastal currents and have accumulated to the extent of forming an immense shoal or bank, across and through which the river flows, dividing it into two strands, called the North and South Bulls, which become dry at low water.

The policy pursued in dealing with the problem has been that of impounding as much as possible of the tidal influx by means of enclosing arms, and the concentration of the outward flow within the limits of the navigable channel, so as to gain the full effect of the scouring action. To this end, two immense walls of embankments have been constructed, one on each side of the estuary—the Great South Wall completed towards the close of the 18th century and the Great North Wall early in the 19th century. In addition, dredging operations have been undertaken, more particularly in the upper part of the channel.

The result has proved eminently successful and the Dublin Port and Docks Board have the satisfaction of administering a port which is not only well provided with shipping accommodation, but which affords safe and convenient access seaward, with a minimum depth of water over the Dublin Bar of rarely less than 30-ft. at high water, and often appreciably more.

Harbour Authorities and Air Transport.

As reported elsewhere in this issue, it will be seen that the Clyde Navigation Trust, the port authority for Glasgow, have taken a very wide and statesman-like view of their responsibilities in regard to the subject of world-wide air transport. Under the auspices of the Trust, a conference has been held, attended by representatives of several West of Scotland Local and other Authorities with a view to reaching an agreed policy for general adoption. The conference after discussion of the matter approved a motion that there should be an International Air Port in Scotland. The initiative in regard to the meeting was taken by Mr. William Cuthbert, chairman of the Trust, who urged that as the Trust, in common with other harbour authorities, provided dock accommodation for shipping engaged in world trade, it was logical for the Trustees to consider the question of aerodrome facilities for transport by air.

We have already in the February issue discussed the desirability of providing harbourage for marine aircraft in port waters, limiting our observations to the accommodation necessary for seaplanes, but the Clyde Navigation Trust seem to have extended the purview of their functions so as to embrace the provision of facilities for land-based aircraft, including aerodromes. In this they are following the precedent set by the Belfast Harbour Board, whose aerodrome at Sydenham on the County Down side of the River Laggan, has been in successful operation since early in 1938. Indeed, it would be difficult in quite a number of respects to lay down any strict line of demarcation between the transportation functions of aeroplanes and seaplanes, and it is better to take a comprehensive rather than a narrow view, since developments in commercial air transport are likely to be drastic and far-reaching in the years following the conclusion of the present world conflict.

The investigation now being made by the Clyde Trustees into the facilities at present available for aircraft and the desirability of providing additional facilities, irrespective of whether they can be provided within the boundaries of the undertaking of the Clyde

Editorial Comments—continued

Navigation Trust will be watched with cordial interest. A report is to be presented at a further meeting of the conference.

Dundee Harbour Development.

In the early summer of last year, the Trustees of the Harbour of Dundee had before them, on the motion of Mr. Henry Main, one of the members of the Board, a consideration of the existing conditions at the Port and the future prospects of the latter as regards trade and development. Following a discussion, the General Manager and Engineer (Mr. Norman A. Matheson) was instructed to " prepare plans showing the possible future development of the harbour regarding additional wharfage and also to include a scheme providing for a dry dock within the harbour area."

Under date of March 2nd, Mr. Matheson presented his report, which has recently been made public. It is a lengthy and detailed document, containing a series of proposals, the general tenor of which is to the effect that a number of the existing works require reconstruction and if this were carried out, a considerable improvement would result, but, as an essential preliminary, the Board would have to decide between the adoption of a policy of Reconstruction and one of Development, since the former would set definite limitations on the scope of the latter.

The report outlines a Typical Development Scheme, fuller consideration of which in these columns must be reserved for the present. The matter, meanwhile, has been referred to a Sub-Committee of the Board and copies of the report have been sent to the Dundee Town Council, the Secretary of State for Scotland, the local Members of Parliament, the Admiralty and the Ministry of War Transport.

Liverpool Shipowners and Cargo Protection.

In the Annual Report for 1942 of the Liverpool Steamship Owners' Association, reference is made to the protection of cargoes discharged on to open quays at Liverpool. The subject has been raised with the Mersey Docks and Harbour Board who have discussed it with the Master Porters' Rates Committee of the Association. Under normal conditions, the responsibility of the shipowner ceases when the cargo is delivered at the ship's rail, at which point, in Liverpool, the master porter takes over on behalf of the consignee. No provision is included in the porterage rate for sheets and skids for protective purposes, any obligation to furnish which is disclaimed by the Dock Board. The Board have firmly maintained this attitude, despite the representations of the Association, which, as a temporary solution of the difficulty and on the understanding that no precedent would be created thereby, has agreed, during war-time, to bear the cost.

But this is only one aspect of cargo protection. Perhaps an even more essential consideration is protection from theft and pilferage. The Association, after discussion in London with the representatives of the Ministries of War Transport, Food, and Supply, decided to set up in Liverpool a special committee composed of the inward freight and other officials of the shipping lines and officers of the importing Ministries to investigate and endeavour to bring about some reduction in the losses in food cargoes and supplies imported from overseas. These losses, though admittedly not disproportionately heavy in relation to the total volume of the commodities concerned, are, nevertheless, substantially greater in war-time than under peace-time conditions. It is the intention of the Committee to determine with some approach to accuracy how these shortages occur and where —whether on ship board, at the quayside or on the landward route to destination, deciding also whether they are actual losses or due to inaccurate tallying or neglect of shipment at foreign loading ports. Losses from pilferage are indisputable; indeed, they are disturbingly large, and this state of affairs will continue, in the opinion of the Association, so long as the courts charged to deal with detected offenders treat the offence as comparatively trivial.

Sir Alfred Booth, presiding at the recent annual meeting of the Liverpool and London Steamship Protection and Indemnity Association had something to say on the same theme. He explained that there were many causes of damage to cargo, such as the use of unsuitable ships, war-time insufficiency of packing, bad stowage, particularly in the unskilful distribution of weights and in the use of frail packages as broken stowage, careless handling, particularly when cargo was worked at night and when dock workers were paid by results, and the use of cargo hooks. With regard to theft and pilferage, the operations of evilly-disposed persons were facilitated by insufficient packing, night-work, the use of berths damaged by enemy action and regulations which prohibited the locking of shed doors. Above all, there was the difficulty of tracing the receivers of the stolen property.

There can be little doubt as to the magnitude and complexity of the problems to be solved. Prolonged and patient effort will be required to produce a satisfactory result.

Quayside Guidance in the Black-out.

Recently, the Port of London Authority initiated a system of guide lamps at their docks in order to minimise the risk of accident during the hours of " black-out." Double and four-sided lamps, specially designed for the purpose, were combined in a code-colour system, and these indicated a safe line of travel from the dock entrance gates to the quays at which shipping was berthed. In the April issue, the *P.L.A. Monthly* announces the success of the measures taken. " It is satisfactory," says the Journal, " to be able to report now that since its introduction up to the end of last year, no cases were reported of seamen being drowned during black-out hours, and only five seamen and two ships' watchmen were immersed. Two of the latter occurred during the foggiest night known for a very long time. A record of accidents for the whole of 1942 shows a great improvement over 1941, the figures for drownings and immersions being as follows:—

	Fatal	Non-fatal.
1942	16	66
1941	35	90

Several of the accidents were definitely known to have been due to seamen and others ignoring the lamp-lighted routes for a slightly more direct way across open ground."

Port Belt Lines.

The article in this issue on the Public Belt Railroad of New Orleans provides an instructive account of the manner in which American port traffic is linked up with the great trunk lines of the country. The practice is somewhat different from that which obtains in Great Britain. Here, with the exception of railway-owner ports, where, of course, the question of divided control does not arise, the general practice is to have exchange sidings in close proximity to the dock area, where a change-over can be made from the railway company's locomotive to that of the port authority and *vice versa*. This system, however, is not universal. There are cases where the dock locomotive enters the railway company's premises to make the transfer and others in which the railway company extends its haulage to the quayside.

The Belt Line appears to be a distinctly American conception, at any rate in its ultimate development, either as an independent organisation of public service, or as a dependency of the port authority. The exercise of port control over railway trackage in the Port of New York by that Authority is extremely widespread, and its Belt Lines serve an extensive area of adjacent territory. At other ports, the jurisdiction of the port authority is not so far-reaching, but usually covers the full extent of port operation.

Generally speaking, it may be said that the special functions associated with the working of a Belt Line in the United States are the reception of outward freight from the trunk lines running to a port, its classification for convenient and expeditious shipment and its transmission to the appropriate wharves and quays, while, in the reverse direction it receives cargo ex ship, passes it through the classification yard and so on to the trunk line system for which it is destined.

The necessity for Port Belt Lines in Great Britain is not very obvious now that the amalgamation of the railway companies has radically reduced the number of separate systems, generally leaving only one to each port. In the United States, the number of independent railway systems serving a single port is, in most cases, considerable. New Orleans, for instance, is served by no fewer than twelve trunk lines; New York has nine lines and a number of other ports anything up to half-a-dozen.

The Port of Dublin

An Historical Account of the Metropolitan Port of Eire

By A. KANE

Ancient Origin of the Port

IT was from the dark-hued waters of the River Liffey, on which the Port of Dublin stands, that the city derived its name. "Dubh-linn," a compound of two Gaelic works, meaning "the Black Pool," was given to it, by reason of the waters of the Liffey being tinged a dark brown by a peat bog which forms the bed of the river.

The first mention of Dublin Harbour was made by Ptolemy in the Second Century A.D. In 150 A.D. it is recorded that Conn of the Hundred Battles, having been defeated by King Mogue of Munster, was obliged to consent to a division of Ireland, the line of demarcation being from Dublin to Galway. Mogue is said to have been afterwards dissatisfied with the partition as his portion did not include the harbour of Dubh-lin. It would, therefore, appear to have been a place of considerable importance even at that early period.

In the ninth century the Danes invaded Ireland, and with their keen eyes for positions of maritime importance, landed at, among other places, Dublin, which they fortified. In 836 the Viking fleet, sailing up the Liffey from Dublin Harbour, plundered Kildare.

The northern bank of the Liffey also witnessed their final defeat, when, on Good Friday, 1014, the Irish, under Brian Boru, conquered them at the Battle of Clontarf and drove them into the sea.

Mediæval History

In the fifteenth century the sea-borne commerce between Dublin and other ports, notably Bristol, had grown considerably, and during the reign of James I, a building known as "The Crane," situated at the end of Winetavern Street, was used as Dublin's first Custom House.

In those days, the harbour suffered the disadvantage of being periodically blocked by a sandbank which allowed only 6-ft. of water at low tide. The first attempt to ensure the safe entrance of vessels appears to have been made in 1577, when a buoy was set to warn ships of the danger of running aground.

Eleven years later the building of a lighthouse at the mouth of the harbour was mooted.

In the State Paper Office, London, there is a report, dated 1590, that the depth of the water at Wood Quay and Merchants' Quay, where vessels then berthed, ranged from 3 to 6½-ft. It is recorded that in 1578, Sir Henry Sydney, when leaving Ireland, embarked at Wood Quay, while ten years later, Sir Henry Perrot, his successor, went aboard his vessel at Merchants' Quay on his way back to England.

The Seventeenth Century.

In 1607, the first effort to reclaim land adjoining the river was made, when a grant was given to Sir James Carroll of a lease for two hundred years, at a rent of £5 per acre, of 1,000 acres of as much of the strand as was overflowed by the sea "between the point of land that joineth the College and Rings' End." He, however, appears to have allowed his lease to lapse, for in 1663, the work of reclamation was undertaken by a Mr. Hawkins.

During the war between England and Holland, the British Government, fearing a Dutch attack on Dublin, sent, in 1672, Sir Bernard de Gomme to Ireland to report on what was necessary to put the harbour in a state of defence.

On his return he submitted to the Government plans for the erection at the Port of a great fortress, at an estimated cost of £131,277. His plans, however, were not proceeded with, and the building of the Pigeon House Fort was postponed for 150 years.

Four years later, in 1676, Henry Howard petitioned the Lord Lieutenant of Ireland, Arthur Capel, Earl of Essex, for a patent to establish a Ballast Board for the purpose of undertaking the dredging and developing of the Port. The Dublin Corporation, opposing his application, claimed that the right was theirs to establish such a Board, and to devote any profits which might accrue to the upkeep of the Blue Coat School.

Howard's petition was turned down, but some time later, he offered, in partnership with his brother, Thomas Howard, to lease

Photo by] Riverside view of the Port of Dublin in the 18th Century. From an [A. Kane etching by James Malton (1792-99).

the Port from the City at a rent of £50 per year. This offer was accepted by the Corporation, and the Howards were granted a lease for 31 years.

In 1685, the question of establishing a Ballast Board was revived, this time by the Dublin Corporation, who petitioned the Lord Lieutenant for a patent. Their petition, however, was not granted, and in 1698, we find the Lord Mayor and the Dublin Corporation complaining to the House of Commons that: "The river is choked up by gravel and sand brought in by the freshwater floods, and ashes thrown in, and by taking ballast from the banks below Ringsend. Whereby the usual anchoring places are now become so shallow that no number of ships can, with safety, bide there, much merchandise being unloaded at Ringsend and carted up to Dublin."

Establishment of the Ballast Office

Nine years were, however, to elapse before any definite action was taken. In 1707, a Bill for the establishing by the Dublin Corporation of a Ballast Office was presented to Parliament, and although opposed by the Lord High Admiral of England, was finally passed, and the Corporation became the conservators of the Port.

In return for this Bill, Queen Anne's husband was to receive yearly one hundred yards of "the best Holland duck sail cloth which shall be made in the Realm of Ireland."

That same year, a new Custom House was erected near Grattan Bridge. It remained in use for 80 years, being afterwards converted into a barracks. It figured in the Emmett Rising of 1803,

Port of Dublin—continued

being one of the strongholds which the ill-fated insurgent leader planned to seize.

Upon their election the officials of the Ballast Office lost no time in beginning work upon the Port. Extensive areas were reclaimed on both sides of the river, and in this work Sir John Rogerson, a wealthy landlord, took a prominent part. He leased from the Corporation an area of 133 acres, which he reclaimed, and the present Sir John Rogerson's Quay is called after him.

Other works carried out by the Ballast Office included the building of the quays, the dredging of the river and the straightening of the channel between Dublin and Ringsend.

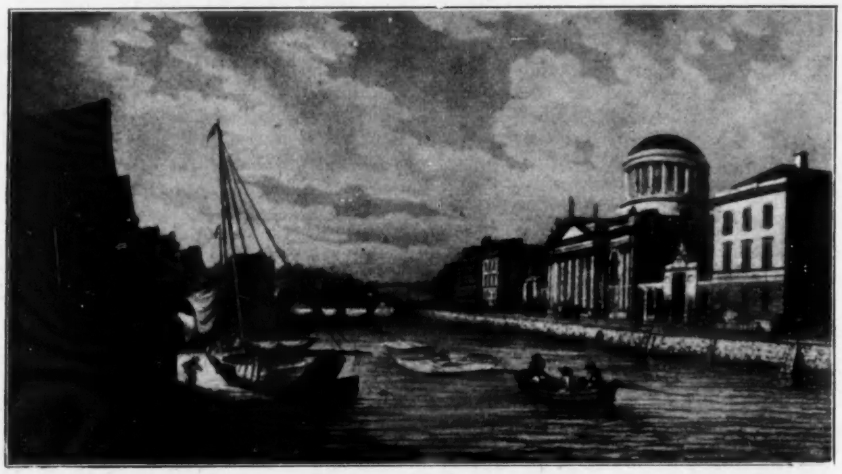


Photo by] A Maritime Scene on the River Liffey in the 18th Century. From an [A. Kane
etching by James Malton (1792-99).

In 1717, the Ballast Office began the construction of the South Wall, now acknowledged to be one of the finest artificial breakwaters in the world. The original breakwater was constructed of wooden piles, but being found to decay rapidly, it was replaced by the present stonework in 1735. In the same year, the Ballast Office placed a lightship at the end of the Wall, thereby enabling vessels arriving at night to enter the Port. Formerly, they had to cast anchor outside and wait until morning on account of the danger of sandbanks.

In 1761, the Poolbeg Lighthouse was begun, and was finished seven years later. This was followed by an extension of the South Wall a further two miles out to the Lighthouse. The work of improving and strengthening this great breakwater went on for almost a century, and it now stretches 3½ miles out into Dublin Bay.

In 1781, the building of the present Custom House on reclaimed ground was begun by the Rt. Hon. John Beresford, Chief Commissioner of the Revenue in Ireland. The architect was the famous James Gandon. The building, and the construction of the Custom House Quays, were completed in 1791 at a cost of close on £400,000. The building, a masterpiece of architecture, is an oblong quadrangle 375-ft. long. Its handsome Doric portico is flanked by open arcades which are carried round the building. Inside there are two courts, east and west. The portico, surmounted by a projecting cornice, bears in the tympanum a sculptured shell drawn by sea horses. Allegorical figures, representing Ireland and England, are attended by a fleet of ships in full sail, and by tritons sounding their shells. The octagonal cupola, rising from the centre, is 113-ft. above the ground. The dome, 26-ft. in diameter, is crowned by a circular pedestal, supporting a figure of Commerce, 12-ft. high, resting on her anchor.

The Custom House Docks Warehouses adjacent to the Custom House, have a wine and spirit storage capacity of 15,000 casks. The area of the spirit vault is approximately 474 by 104-ft. The mean temperature is 55 to 60 degrees, and the maturing period about 16 years.

There is also storage for 10,000 tons of grain, 30,000 hogsheads of tobacco and 10,000 tons of general merchandise. The Custom House Docks were constructed by the Government at a cost of £700,000, and transferred to the Dublin Port and Docks Board in 1866 on payment of £31,819.

The task of building up Dublin Harbour to its present position of importance, was one of tremendous difficulties. John Rennie, the famous engineer, wrote about the undertaking: "The improvement of Dublin Harbour is, perhaps, one of the most difficult subjects which has ever come under the consideration of a civil engineer."

At one time, the abandonment of the Port was actually under consideration, and proposals to make Sutton, Howth, Dun Laoghaire (Kingstown) or Sandycove, the Port for Dublin, were put forward. However, by means of tenacity and sheer hard work there finally emerged the navigable channel as we know it to-day, leading straight to the heart of the metropolis, the area of reclaimed land on both sides totalling 608 acres. The immensity of the task of making Dublin Harbour accessible to shipping may be gauged from the fact that within a period of 70 years the Port Authorities had dredged from the river bed 50 million tons of detritus.

On the northern side of the river, the North Wall Extension, provides berthage for vessels up to 26-ft. draught. The Alexandra Basin, with a water area of 60 acres, can, at all tides, give berthage to vessels of up to 32-ft. draught. Along the North and South Walls there is also berthage of 3½ miles, and a quay frontage of 30,116-ft.

In 1787, the care of the Port was transferred from the Ballast Office Department of the City Corporation to a special body known as the Corporation for Preserving and Improving the Port of Dublin. It was briefly referred to as the Ballast Board. It existed until 1867, when the Dublin Port and Docks Board, established under the Dublin Port Act of 1867, succeeded it.

In 1813, the building of the Pigeon House Fort on the South Wall was begun. It was completed at a cost of over £100,000, and accommodated 700 officers and men. In 1897 its use as a defence work being discontinued, it was dismantled and sold to the Dublin Corporation for £65,000. It is now a municipal undertaking.

In 1898 the Dublin Port and Docks Board was reconstituted in its present form, and its personnel made up of the Lord Mayor of Dublin, six members appointed by the Dublin Corporation, twelve trader members and nine shipping members. The Board has since successfully carried out all the business of the Port, including towage and pilotage, the latter being compulsory at Dublin.

Development of Turkish Ports

Some months ago, it was announced that the Turkish Government had entered into contractual relations with the United Kingdom Commercial Corporation for the construction of harbour extension works at the Ports of Alexandretta and Mersin, in Asia Minor. Later reports show that the development programme covers the construction of a deep-water pier at Alexandretta, with other harbour improvements and the completion of the existing pier at Mersin. The Alexandretta pier will be a quarter-of-a-mile in length, the second largest in Turkey. It will be capable of berthing large ocean-going vessels and will be equipped with shed accommodation, railway sidings and quay cranes. The pier of Mersin will have facilities for handling about 1,000 tons of merchandise per day. Both ports have rail connection with Aleppo in Syria, and, in this way, are able to be linked up with the important commercial centres of Beirut, Haifa, Port Said, and Alexandria, as well as with the Iraq State Railways, *via* **Mosul.**

Harbour Breakwaters*

By MARCIANO MARTINEZ CATENA, Engineer of Roads, Canals and Harbours.

I.—Mound Breakwaters

Introductory

THE breakwaters of a harbour constitute its main element of defence and are the means of securing internal tranquillity in the face of heavy storms.

The forces produced by masses of water in motion are so powerful that it is not surprising that, until recent years, the lack of knowledge on a subject so essential to harbour engineering was almost complete, even to the extent of accepting a type of breakwater termed " composite," intermediate between the rubble breakwater and the wall breakwater, which to-day should be altogether proscribed.

To design a structure exposed to unknown forces was the problem set, and to it was given a solution based on a consideration of similar works already constructed, with some inevitable misgiving as to what would happen when it was completed. What form to adopt? What dimensions should be given to the adopted structure?

Engineers of all countries have devoted their activities towards bringing enquiries of so absorbing a nature within the limits of technical knowledge. Systematic observations on works constructed with success, conscientious investigation of the damage wrought by the sea, laboratory experiments with reduced scale models and the estimation of the forces to which breakwaters are subjected, either directly or by means of mathematical formulæ, are matters which have been investigated, bringing a good deal of light to bear on the assumption that if there are no definite data, there is sufficient guidance to reassure the engineer who designs a maritime protective work in the light of actual knowledge.

Breakwater Types

There are two types of breakwater: breakwaters with a sloping face and breakwaters with a vertical face.

These are the only two permissible forms. The arrangement of the first has the object of inducing the breaking of the wave so that it may dissipate its energy while mounting the sloping face.

The arrangement of the second is for the purpose of avoiding the breaking of the wave, merely reflecting it from the vertical front.

The force of broken waves is unknown. Their effects are catastrophic and consequently it is necessary either to bring about their rupture in such a way that no damage can be caused on a sloping face by an appropriate inclination, or of avoiding it by diverting it from a vertical surface, into depths which do not induce rupture.

Vertical face breakwaters offer the following advantages over sloping breakwaters:

1. Greater economy.
2. Greater rapidity of construction.
3. The cost of maintenance is almost nil for a vertical wall, which is not the case with a mound surface.
4. With the same or equal disposition of the axis of the breakwater, the navigable sheltered area is greater in the case of a vertical wall, by reason of the encroachment of the interior slope of the mound breakwater.
5. Vertical wall breakwaters provide berthage, which is not available with a sloping mound, and which can be utilised for the supply of oil, fuel and water and for the landing of passengers.

On the other hand, they possess a serious inconvenience. Damage caused by storms tends to be disastrous, since destruction is almost total, which is not the case with mound breakwaters.

The selection of one or the other type is based, as in all engineering matters, on economical grounds. Local circumstances can render prohibitive the use of the second type. The adoption of a mound breakwater is compulsory in the three following cases:

1. Location of the breakwater in depths which cause the rupture of waves in heavy storms.
2. Location of the breakwater on a muddy bottom or a bottom disturbed by heavy wave action.
3. When the alignment of the breakwater is such that its axis forms with the direction of advance of the storm waves normal to the crests and troughs, an angle less than 45°.

In these three cases, there is a veto on the adoption of a vertical wall: in the first, because the wave will break against the face; in the second on account of the instability of the built-up structure, and in the third because the wave is not reflected, but will traverse the length of the breakwater with unascertainable result.

FORCES TO WHICH BREAKWATERS ARE SUBJECTED.

Wave Characteristics

Waves are defined by their characteristics, viz.:—

Range = 2 h
Length = 2 L
Period = 2 T

Before explaining the practical measures which must be adopted in determining these characteristics for the largest waves, which may be in action over the breakwater under consideration, we will make a brief historical resumé of the undulatory movement, taking into account the fact that the waves are waves of oscillation, which conform to the hydrodynamic laws of trochoidal motion.

There are waves of oscillation and waves of translation.

The distinguished scientists, Weber, Russell and Bazin, have experimentally investigated these waves, enunciating the following principles:

(a) Waves of oscillation are produced by vertical action and those of translation by horizontal action.

(b) In waves of oscillation, the disturbance is not propagated throughout the entire depth, while in waves of translation it is.

(c) The wave of oscillation in free propagation diminishes gradually in height and length; this does not happen in waves of translation, which tend to retain a definite form which does not alter if there is no change of depth in the liquid.

(d) Both waves, propagated in gradually decreasing depths, break when the depth becomes equal to the wave height.

(e) Both waves break when their length is approximately equal to three times their height.

(f) The volume of waves of oscillation increases with their height and length, and in waves of translation, with equality of volume, the wave can possess very different heights and lengths.

(g) In waves of oscillation, if the depth of liquid is greater than the length of the wave, the speed of propagation is independent of the depth and is:—

$$v = \sqrt{\frac{gx^2L}{2\pi}} = \text{approximately } 1.25\sqrt{2L} \ldots (\textit{vide} \text{ note at end})$$

In waves of translation, if their length is very great in relation to the depth H in which they are propagated, their velocity in calm water is

$$v = \sqrt{g(H+2h)} = \sqrt{2g\frac{H+2h}{2}}$$

*Translated from the Spanish Article, "Diques de Abrigo en Puertos," in the *Revista de Obras Publicas*, July, 1941.

Harbour Breakwaters—continued

and in moving water with velocity u

$$v = \pm u + \sqrt{g(H + 2h)}$$

(h) In waves of oscillation, the maximum height and velocity are connected by

$$A = \frac{2v^2}{g} \text{ and since } v^2 = \frac{gx^2L}{2\pi}, \; A = \frac{2L}{\pi}$$

In waves of translation, if the depth of liquid is very great with respect to the height:

$$v = \sqrt{gh}$$

By experiment, moreover, it can be shown that a wave in which $2L < H$ is propagated as a wave of oscillation and that if $2L > H$, it is propagated as a wave of translation.

The trochoidal theory is in harmony with the foregoing experimental conclusions. They were enunciated in the first instance by Von Gerstner and, afterwards, were studied by Airy and Boussinesq.

Later, Flamant and Saint-Venant have developed them, publishing their conclusions in the *Annales des Ponts et Chaussées* for the year 1888 under the title: "De la houle et du clapotis" (concerning wave swell and reflected waves) and the reader will there find them.

These waves of oscillation are those which act on breakwaters and their effects are greater with an increase in their characteristics, 2h, 2L and 2T. Now, the determination of these characteristics is a delicate matter if account is taken of the following considerations:

1. The difficulty of appraising the said characteristics, particularly the height, is shown by fanciful estimates of the height of storm waves put forward by seamen in maritime publications.
2. That this kind of work is constructed for an indefinite future, in the course of which storms of exceptional violence may take place.
3. That maritime works are the only kind in which engineering designs are made without introducing a factor of safety. For all these reasons it is necessary to be particularly cautious in fixing 2H and 2L.

The causes of many disasters to maritime structures have been exceptional storms, unforeseen when the works were designed. In the case of the Mustapha Mole at the Port of Algiers, a work designed in 1923 for the heaviest seas to which it was likely to be subjected, believing these to be 5 metres in height and 80 metres in length, the work was destroyed in February, 1934, by a tempest in which were clearly recognised waves of 9 metres in height and 200 metres in length. The breakwater at Autofagasta was designed on the assumption that the greatest waves would be 6 metres in height and 90 metres in length; in the first accident to this breakwater in July, 1928, the storm waves, which did the damage, were estimated as 9 metres in height and 250 metres in length.

If the foregoing considerations seem to be more strictly applicable to breakwaters with sloping sides, yet in the design of breakwaters with a vertical face, such extremes should none the less be taken into account since the accidents which result are grave and may ultimately cause the total collapse of the work.

BREAKWATERS WITH SLOPING SIDES, OR MOUND BREAKWATERS.

Mound breakwaters ought to be adopted in the following instances:

1. When the depth of water on the site is less than 4h (2h = amplitude of maximum storm waves).
2. When, with depths greater than 4h, the bottom is of mud or quicksand, easily disturbed and of a density which impedes dredging.
3. When the axis of the breakwater makes with the line of advance of storms an angle less than 45°.

In the remaining cases it will be necessary to compare this form with that of the vertical wall to decide which is the more economical.

Mound breakwaters are constructed with the following constituents:

1. The Core or Nucleus;
2. Protective cover for the Core;
3. Parapet or Crest.

This last feature is not essential

Figs. 1 and 2 show what ought to be considered the typical transverse section of a mound breakwater, consisting of the three constituents above mentioned.

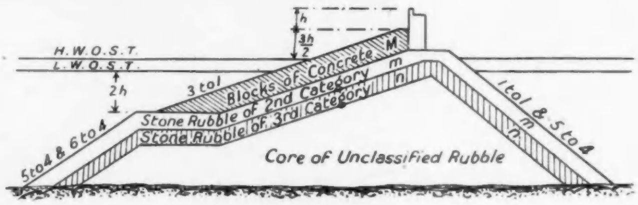


Fig. 1.

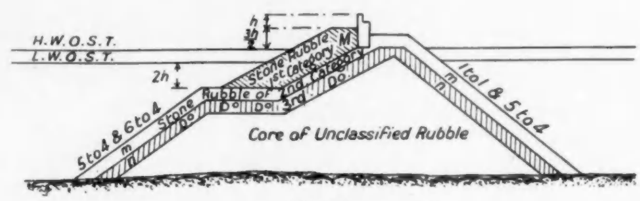


Fig. 2.

On the exterior face are two different slopes: one, gentle, the inclination of which will be considered later, since it is that which causes the breaking of the wave and on which it wastes its energy, and which extends $\frac{3}{2}$ h metres above high water level to 2h metres below low water level; and the other in natural equilibrium, extending from this level to the bottom.

On the interior face, there is a single slope, which is that of equilibrium.

1. **The Core or Nucleus.**—This is the chief element of resistance of the breakwater, serving as support to the protective cover.

The external swell ought not to be propagated into the interior of the harbour through the breakwater and it is the function of the core to prevent this; accordingly, it consists of quarry materials of different sizes in order to attain the maximum degree of compactness with the minimum of cavities. Theoretically, it would have to be designed with rubble of different sizes, mixed in such a way as to attain a granularmetric material of the highest compactness, equal to that made in the dry for concrete. Practically, this is impossible for economic reasons: it is necessary to utilise such material as comes from the quarry; on this account it is essential to assign to the core all the material which comes to hand, limiting its minimum size, since, bearing in mind that this part of the work is to be formed by precipitating the material from a barge at water surface level, the least weight of each fragment must be sufficient to collocate it accurately in the work by the action of gravity alone, in spite of possible swell and current.

The outer slopes of the core will be governed by those of the area of the breakwater and will always be such as can be realised by means of barge discharge.

The case is not the same on the interior face, where, if there is sufficient width in the breakwater, the slopes can be formed by direct tipping of material from a track located on the crest, by means of which it is feasible to obtain a slope of natural equilibrium.

2. **Protective Covering of the Core.**—In a core constituted of material of all sizes, the smallest fragments would tend to be swept away by wave action, if steps were not taken to provide the slopes with protective cover consisting of pieces of sufficient

Harbour Breakwaters—continued

weight not to be swept away themselves and so arranged as to prevent the disturbance of the nucleus. These coverings we propose to classify as principal and secondary.

a. **Principal Protective Covering.**—This is indicated by M in Figs. 1 and 2. Located in the zone most battered by the sea, it is the most susceptible part of the work since to it is entrusted the resistance to the shocks to which the breakwater is subjected—shocks of extreme violence, such as those produced by waves when breaking. The success, or failure, of a mound breakwater depends altogether on the principal protective covering. The under-water slope of this covering causes the breaking of the wave, and over the part above the surface the wave rises tumultuously in the course of expending its energy.

The principal protective covering has to be determined in respect of its thickness, slope and levels as far as they are prolonged above and below water level.

The following particulars are required for its design: the greatest storm waves recorded at the site of the breakwater as defined by the amplitude 2h and the length 2L, and the weight of the fragments included in the covering. The characteristics of the waves, we have already considered, and as regards the weight of the fragments, this depends on the quarry, if it is that which supplies suitable material, or if not, on the dimensions of the artificial blocks, taking account of the means at disposal for placing them in position. The determination of the size of the pieces which will form the principal protective covering is, therefore, an economic problem to be settled by the material available in each case, taking into account moreover what the calculation of the slope will require.

Having determined the data, the unknown factors are deducible on general lines as follows:

The thickness of the covering will be such that if the pieces which form it are artificial blocks, they must be arranged as two layers and consequently the thickness will be twice the least dimension of the parallelopiped blocks. If the pieces are natural stone, they should be arranged in three layers, and as the fragments of each layer should partially engage in the cavities of the one below, the thickness can be deduced. It is obvious that the three layers in question are the minimum permissible.

As regards the slope, the distinguished Spanish engineers, Castro and Iribarren, have given formulæ* which decide it, the weight of the fragments and the characteristics of the wave being known. The flatter the slope, the greater its stability, but it augments the mass of the work. The determination of the slope is a problem, technical and economic, which has to be settled with a consideration of all the factors involved.

(To be continued)

* Castro, "Diques de escollera" in *Revista de Obras Publicas*, 15th April, 1933 and Iribarren, pamphlet on "Una formula para el calculo de los diques de escollera," July, 1938.

Note—There appears to be some slight obscurity in the equations, which are reproduced exactly as in original text—Editor.

King's Lynn Docks and Railway Company.

The accounts of the King's Lynn Docks and Railway Company for 1942 show a net revenue of £6,874 as compared with £5,363 for the previous year.

Salvage of a Stranded Floating Dock Section.

A section of a dry dock, required for the completion of the structure, was recently being towed to a United States port, when it broke loose in a gale, and went aground at an isolated point on the Massachusetts Coast, so difficult of access that, at first, all hope of refloating the section was abandoned. However, in view of urgent necessity, it was decided to make an attempt at salvage, which, happily, was successful six weeks after operations were started. Men of a contruction battalion, working in Arctic weather and heavy seas, built a temporary pier to the stranded dock section and this provided access for workers and material for repairing the damaged hull and making it water-tight. Rock-blasting was then undertaken to free the section and this enabled it to be floated out into deep water.

Notable Port Personalities

XXXVI—Mr. Mark H. Gates

Mr. Mark H. Gates, President for the current year of the American Association of Port Authorities, was born of English parents in California in 1878, his father being Mr. Frederick Gates, a gun-maker, of Derby, in England, and his mother, previous to her marriage, Miss Sarah J. Woodland.

Mr. MARK H. GATES.

While employed, early in his career, as a salesman in the wholesale hay and grain business in San Francisco, Mr. Gates handled all the shipping business of the firm on the city waterfront. Then he spent three years in railroad freight operation and several years after that in accountancy and auditing of all kinds. He devised and introduced a cost-accounting system for the United States Reclamation Service on the Yuma Project, Arizona, and remained for two years in charge of it. He also spent about 14 years on the staff of the San Francisco Bureau of Governmental Research, becoming secretary and, for the last two years, director.

In 1927, Mr. Gates was appointed Executive Secretary of the Board of State Harbour Commissioners of San Francisco, the premier port on the Pacific Coast, a position which he still holds. He has taken an active interest in the California Association of Port Authorities, the Pacific Coast Association of Port Authorities and the American Association of Port Authorities, of which last named he is now President, holding various offices and being chairman of a number of committees in all these bodies.

Obituary.

The death has occurred of **Mr. William E. Houston,** port and harbour engineer at Londonderry. He was responsible for carrying out many improvement schemes at the port, notably the Queen's Quay extension, which cost approximately £50,000.

The death has also occurred, at the age of 77, of **Mr. Thomas Fogg Davison,** of Sunderland, who retired recently from the post of chief cashier with Messrs. Smiths Dock Co., Ltd., North Shields. He had been chief cashier with the firm for 23 years.

Head foreman for 15 years to the Middle Docks and Engineering Company, South Shields, **Mr. J. Slavery** has died at the age of 67.

Rice and Rice Handling

A Notable Commodity at the Port of Bombay

By E. J. KAIL, Bombay Port Trust.

Sources of Supply

From time immemorial the fruits of the soil have been a favourite theme with sage and bard, and for this reason, agriculture has been fervidly commended as the most important and useful of all occupations in civilised countries—crop farming being in consequence the main line of utility. This is, indeed, so from the point of view of food production alone, and not of wealth and power. Grain and cotton may be considered two great sub-

Rice discharge from sailing craft at Bombay.

divisions in agriculture, with rice taking the lead in the former. Though wheat and maize are admittedly very substantial and highly sustaining food grains for the peoples of a very large area of the universe, yet rice provides more foodstuff in bulk, if not in vitamins, for the support of the human race the world over, than any other cereal grown on the earth's surface. If in the piping times of peace, the adage " as you sow, so shall you reap " was considered proverbial, if it was not prophetic, how much more important and indeed vital, are the fruits of the soil in times of a life and death struggle and an all-embracing conflict? Indeed, to nearly half of the globe's inhabitants, rice affords the main item of diet. Through the centuries it has been the principal crop of the East—of the peoples of India, China, Burma, Malaya and the Far East, where 80 million tons is considered a good year's yield. Over 50 million acres are under rice in India, and a larger acreage in the Far East and Malaya. Its cultivation in equatorial region has however spread with advantage northwards to less torrid zones, and to-day rice is grown in Spain, Italy, Central America and North Africa—but paradoxical as it may seem, the best in quality is said to come from Carolina, one of the United States of America. European countries, too, use large quantities for various kinds of food, as well as for refreshment both solid and liquid. Though it cannot be turned into bread, as it contains little gluten, it is in consequence largely boiled and curried or dressed; but whether it is the *piece de resistance* or a dessert, it is a favourite everywhere, to prince and peasant, mahout and mandarin, being the staple food of the peoples in the thickly-populated monsoon regions of the globe, to whose soil and climate it is so peculiarly suited, and to which it primarily belongs.

Cultivation

The rice plant is a member of the great and important grass family, but differs from most of its members as it is essentially a wet plant, and requires a soil flooded beneath a few inches of water for the seed to germinate. The young plants grow up through the water. It is entirely different from all other food grains. It must be sown in loomy earth. Rice or paddy fields, usually ploughed by water buffaloes under an old-fashioned wooden plough, are generally arranged in " nurseries " for flooding. The seed is either thickly " broadcasted " or sown in rows, and remains covered with water. When the young shoots are 6 to 9-in. high, they are transplanted in small tufts, but again under water, the roots being thoroughly submerged till the plant has attained a good size. Then the fields are allowed to dry, and the grain ripens in spikelets by the action of the sun, the harvest usually being at the end of the cold season, when only one crop is cultivated. Plenty of water and flat land are two essentials for a good yield. The great alluvial plains and river deltas of tropical countries are the best rice land. The Ganges, the Irrawadi, the Mekong, and the Si Kiang, with the ports of Calcutta, Rangoon, Saigon and Hong Kong to bear witness. In hilly places, paddy fields are terraced in broad flat steps. Paddy is the English equivalent of the Malay word " padi," which means rice with the husk on. Generally, rice requires 60 to 80-in. of rain to do well, but irrigated or canal areas in India and Burma also yield bumper crops. In the monsoon regions, the seed is sown during the rains, and is ready for cutting in the cold weather. Near the equator, the two rainy seasons allow of two crops to be raised, but it is an axiom that more rice is grown where the inhabitants are civilised. It is, in truth, an occupation for the middle classes with a stake in the land and all that means to them and their heirs. The rice lands of South China produce three crops a year, to feed the teeming millions. Men, women and children work all day for long hours almost knee deep in the wet and muddy fields. They thresh, winnow and " hull " the grain, separate it from the rusk. Wherever these cultivators may be, they toil in slimy mud, with legs bound round with cotton strips to protect them from blood-thirsty leeches, heads covered with large mushroom-shaped hats plaited from rice straw, and faces protected from the awful bite of the mosquito. Their bodies are almost doubled whilst they thin out by hand the plants, grown earlier in the season. Fever lurks in the swampy ground. It is, indeed, hard work and not a healthy occupation, but the yield is bountiful and pays for the trouble, whilst millions thrive on it.

The annual preparation of the fields may be witnessed in different stages. In April and May, the land lies fallow, rank with weeds and grass. From then on to July, the peasants are continuously engaged clearing the soil, squatting in the water splashed with mud, preparing the almost uniform chequer of squares of brown earth, in which the seed is sown and which are enclosed with mounds of mud called " bunds," whereon bean stalks and vegetable creepers may also with advantage be grown and utilised. The browner and muddier it is, the more these peasants rejoice, for a heavy crop will be sold to the mills of their districts. Early in September, the " Children of the Padi," the young rice shoots, are taken from their nurseries and transplanted to the beds made ready for them. They flourish in the rain, or in the water accumulated in the irrigation reservoirs near by, and change colour from a light straw to a delicate and then to a vivid green; they are a nursery box of " paints green." Months pass whilst the plants mature. The fields are white with the harvest from December to February, and reaping lasts till early April when a single crop season ends. No one can look unmoved on the closing scene. Vast sheets of the bountiful grain, which means so much to toiling humanity, catch the eye. Mounds and mounds of the cereal provide the sinews to fulfil the cultivator's desires. Emblems of prosperity, jewellery, a good feast for the

Rice and Rice Handling—continued

elder daughter's wedding, minds unburdened with thoughts of lurking and strangling debt, good food and gossipy feasting, all these can be had and enjoyed. Peace and plenty, both are here in full measure, for the peasant and the seed, the latter pressed out and overflowing. Irrigation schemes, thanks to the advance in agricultural implements and machinery, do not hedge or quail in fashioning these lands; they work to surmount obstacles, and eventually find the horn of plenty. The irrigation canal, or reservoir, will gush forth its waters on the slime and ooze, and peace and plenty follow in their train.

Transport

The paddy is brought down the great alluvial rivers in large ornamental boats to tne sea ports, where it is usually milled for husking, whitening, polishing and grading. During the last process, the rough broken grain is separated from that which is intact, and then both categories are graded into several classes. After this is done, the cereal is weighed and bagged for the surplus to be sent across the seas. Rice is also faced, or glazed, not only to give it an attractive appearance, but more so to protect its surface and quality from deterioration by exposure. Apart from its use as a repast, rice has been put to a great variety of other purposes. The stalks of the plant are turned into straw for head wear, the husks of the seed are utilised as fuel, and rice bran containing particles of the grain, is in great demand for preparing feed cakes for cattle. Broken rice is largely used not as food, but in the brewing and distilling of trades, as well as for the manufacture of starch and rice flour. A poultice of pounded rice as a palliative or cure in illness is an effective home remedy of very long standing. Strangely enough, the so-called "rice paper" is not a product of the rice plant, but from a small tree of the ivy family grown in Formosa.

Marketing

Turning from the crops to the markets they serve, it is a truism that the volume of rice exports is largely determined by the monsoon or water supply, as well as by the density of the population of the country who grow the cereal. A good monsoon and small man power will naturally encourage export of all spare produce. India and China, the largest rice-growing countries in the world, sharing 60 million tons a year between them, have little to spare for shipment overseas, just because their own economic needs have the first and most urgent call. Rice was exported mainly from Burma, and then from Siam and French Indo-China, where plenty of rain and a sparse population stimulate overseas trade. However, the export of rice from all countries is but a twelfth of the world crop, the home market being the main customer, and more so to-day. Though India produces several million tons, Bengal alone accounting for almost half the yield, exports to other countries are but a mere fraction of this off-take, whilst Burma, on the other hand, with many less mouths to feed, can release over 50 per cent. of her turnover, which is a third of that of the whole of India, for consumption elsewhere. A tenth of Burma's shipments did reach Bombay every year, the rest going to various centres all over the globe, a large slice being taken by Great Britain.

Rice Trade at Bombay

The import of rice into Bombay, an eighth of the city's inward trade, is a matter of considerable importance to the town, the province and the port. Though there are several varieties of rice (at an exhibition in Calcutta, 4,000 different varieties were on view), about 125 main sorts are imported into Bombay. They are commercially classified as white, boiled and broken; but approximately 90 per cent. come under the first heading. The Port of Moulmein exports the largest number of qualities, and Saigon the least, whilst the highest in grade is also raised round Moulmein. Incidentally, it may be stated that the actual opening of the Alexandra Dock, Bombay, to traffic in March, 1914, was completed by the berthing of a ship carrying a rice cargo from Burma. The first sling load of rice to break bulk off the vessel was landed on the quay with due ceremony and felicitation, acclaimed with religious ritual, and blessed with every good wish for the prosperity of the docks, the city and province of Bombay.

In a large shipment from Burma, most of these varieties under as many as 400 main shipping marks, may occur, though consigned to a lesser number of importers. Their clearing agents, or cammadums, however, are few, hardly a dozen, which is an advantage when disposal of several bags bearing incorrect or no shipping marks stencilled on them await settlement. These shipping marks with the quantities of each lot, appear on the ship's inward manifest, and a judicious allotment of transit shed space in the docks is indispensable for good sorting and stacking of the various marks and parcels, whilst it will make for expeditious and satisfactory deliveries of the various lots. An ingenious, but very effective, method of counting the bags into the landing shed, called "Stick Tally," entailing the use of 500 cane sticks from one box to another by each gang of labourers has to a large extent eliminated errors, whilst it facilitates rapid discharge of the cargo; and a practical and vigilant system of daily check on deliveries from the docks by bullock cart, motor lorries, railway wagon or

Unloading bags of rice at the quayside, Bombay.

country craft, to other coastal ports or centres, both devised in the hard and costly school of past experience, have undoubtedly resulted in the satisfactory out-turns of rice cargoes landed in the Port of Bombay, thereby short circuiting thefts and loss of commodity, which is easy to handle and commands a ready sale.

Handling Cargoes at Bombay Docks

A vessel carrying a full load of a lakh of bags of rice of nearly 7,500 tons deadweight (a large vessel may lift a lakh and a half), is an object of interest in the Bombay docks. The ship is down to her marks or load line, and often in line or below quay level, if the tide is low. In no time, the dock cranes and ship's derricks are moved into position, swarms of labourers to work both on board and on shore arrive alongside, hatch covers and beams are removed off the ship's holds and 8 or 9 well-oiled cranes and winches begin to operate steadily from the ship to the shed, each with a load of 17 or 18 bags, and back again at intervals of about 2 minutes. These cranes will deliver the goods on all three floors of the shed, whilst the tally clerks and stick-men, the sorters, the sewing men and the supervising staff are already at their posts. Each shore gang will consist of at least 20 selected labourers, who, between them, will lift close on 4,500 bags a day from the rope slings which bring the rice ashore, and stack them high on all floors of the shed in their correct lots, properly tallied and carefully sorted. Each man carries a distinctive head gear called a "gadi," made of hessian and carefully interwoven, which distributes the weight of the bag on his head and shoulders without interfering with his movements in running to the sack and tipping the bag over to its proper place in it. He individually lifts about 225 bags in a working day of 9 hours, and as the gangs work on a piecework basis, their remuneration is higher than that of other bag-cargo labour. The labourer is, indeed, worthy of his hire,

Rice and Rice Handling—continued

for at the close of the day, at least a third of the ship's cargo will be discharged, and if the vessel works day and night, as most vessels do, 48 hours will suffice for daylight to penetrate into the innermost recesses of the vessel, which, by now, is clear of her cargo, and riding high out of the water, ready to turn round and carry another load. Meanwhile, the Clearing Agents and " muccadums " have not been idle. They have completed and collected their shipping documents; their fleets of motor lorries, and rakes of railway wagons are lined up ready for action, and they make a start, vieing with each other, to shift their consignments a day after they are landed. For the next five days the rumble of feet on the floors of the shed, the thudding of bags down the shed chutes into lorries or wagons, the quick movement of the former out of the dock gates to the godowns and back again, and the slower procession of wagons with bell, flag and puffing billy

Weighing bags of rice at the Port of Bombay.

out of the dock to distant destinations, will be the order of the day. When country craft are loaded for the ports on the West Coast of India as their destination, this operation parcelled out in lots of a hundred bags on the quay for ready counting and loading will proceed along with the other two. After the last free day for clearance has expired, five " free " days clear of demurrage are permitted from the general landing date of the cargo—the shed will be left with hardly two thousand bags, a bare 2 per cent. held over for survey, or of consignments, whose documents of title have not arrived; and within the next few days these, too, will be moved out. It is indeed remarkable that the consignees of rice cargoes, however, substantial they may be, are, like absentee landlords, never seen in the docks. Their clearing " muccadums," a hard-headed and assertive conclave, do all the spade work, and shoulder full responsibility. It should not be considered that once the greater part of a rice cargo is moved into the town, it will be allowed to stay there. The parcels will be quickly sold in smaller lots and weighed over to buyers for despatch further afield. Motor lorries will carry away the bulk of this trade, some of it to the railway yards, but a goodly portion over the Western Ghats or Hills of the province to far-off destinations. There are no townships in India where rice is not appreciated and consumed, and, in quick time, motor and rail transport will find and serve them.

Demurrage

When bumper crops of rice are exported from Burma, Indo-China or Siam, fluctuations in price, among other reasons, speculative or unforeseen, lead to a glut in the market and consequent shortage of godown accommodation in the town. With a rising tide of bags to be cleared, consignees then turn to the Bombay Port Trust for the storage space they so urgently require, and thus avoid the accrual of heavy demurrage charges. Such a situation arose two years ago, when Bangkok and Saigon competed with the ports of Burma for a place in the Bombay market. However, when the wave arrived, there was, to the good fortune of all parties, sufficient space in the dock warehouses to take over 20,000 tons of the grain, which remained on the Bombay Port Trust premises for a few months, till the position was eased and they were absorbed in the town elsewhere. A similar hiatus also occurred with other cereals imported into Bombay, such as wheat and sugar, and had ample accommodation not been readily available, there would have been congestion at the docks, shipping would have been delayed, prices would fluctuate, and the ugly head and strident tongue of discontent and dissatisfaction seen, heard and felt everywhere.

Saigon and Bangkok rice is of different and inferior quality to that from Rangoon, and the shipping marks are in consequence considerably less. It is, therefore, possible to store a larger quantity bearing one or two marks in a given space than it would to take several smaller lots of various marks, which is a decided advantage when thousands of tons await accommodation.

The Bombay Trust warehouses are meant primarily for the storage of sea-borne goods on which Customs duties are recoverable, or which are cleared after examination through the Customs free of Imperial duty. Saigon and Bangkok rice come under the latter category, and were therefore able to take advantage of the facility for storage.

Conclusion

The foregoing account is but a brief review of a cereal, whose cultivation and export is of the utmost importance to nearly half of the inhabitants of the earth. The sowing and reaping of the crops lays a heavy hand on the labour of several hundred thousand agriculturists in each district of the rice-growing countries, and on their efforts and success depend the happiness and welfare of many more million consumers. The material prosperity of hundreds of thousands of workers, in the fields, at the river side, the mills, docks, godowns and retail shops, is entirely controlled by the crop, its size, quality, distribution and market. Restriction and loss of acreage has, however, created a problem for the consumer, affected its distribution and lastly inflated the cost of the grain. If the mustard seed is a symbol of the fertility of the soil, rice is an emblem of its bounty and usefulness. For these reasons during various ceremonies in Eastern countries, religious, nuptial and dedicative, rice plays an important and symbolic part. It enters into the ritual of most of these important occasions, being considered a good augury for the initiation of a project or on the embarkation of a new venture in life, work, happiness or recreation. It is essentially an emblem of peace, happiness and prosperity. No other food grain makes the same appeal to the toiling millions, no other seed is of the same value to so many. Its comparative cheapness in cost, its abundance, and simplicity in serving as food, give it an assured place in the family budget of hundreds of millions spread over an infinite variety of lands almost as different as the variations of the grain itself. Though its cultivation dates back to the dim and distant ages, to the days of Confucious and the Pharoahs, its present, virtility, abundance and popularity show no sign of diminuation or decay, nor does its value as an essential food grain to the people of both hemispheres of the universe.

Notes of the Month

Dry Dock Appointment.

Mr. Angus Lisle, hitherto in charge of repair work at Willington Quay, Newcastle, has been appointed works manager to the Mercantile Dry Dock Company, Ltd., of Jarrow.

Improvements at a Mexican Port.

Extensive dredging operations are being carried out at Mazatlan, the leading Pacific port of Mexico, in order to provide accommodation for more naval and mercantile shipping than is possible at present.

Administration of Palestine Ports.

Port management in Palestine is about to be transferred from the Customs Authorities to the Railways Department, without, however, interfering with the normal fiscal duties of the former.

New Graving Dock at East London.

The Union of South Africa Government confirm their intention of building at East London a graving dock with the following dimensions: Length, 650-ft.; width of coping level, 80-ft.; depth of water over sill at L.W.O.S.T., 29-ft.

Royal Visit to Tyneside.

Their Majesties the King and Queen paid a visit to Tynside on April 7th and made a tour of inspection of shipyards and electrical works. They were received at the quayside by Sir Arthur Sutherland, chairman of the Tyne Improvement Commission, and sailed down the river in the Commissioners' launch. A number of presentations were made.

The New Duncan Dock, Cape Town.

The large new basin recently completed in Table Bay, South Africa, was officially designated the Duncan Dock at a ceremony on April 20th, by the Acting Governor-General of the Union, Mr. Justice N. J. de Wet in the presence of Lady Duncan (whose husband, Sir Patrick Duncan, is incapacitated by illness), Field-Marshal Smuts and members of his cabinet, as well as foreign diplomats.

Canadian Gift to Port of London.

A mobile kitchen to supplement the static and mobile canteen service at the docks of the Port of London has recently been presented to the Port of London Authority by the Order of the Eastern Star, a fraternal organisation in the province of Ontario, Canada. The kitchen is one of 25 which have been given by the organisation and distributed in various parts of Great Britain. It is the second which has been presented to the Port of London.

New American Floating Dock

A floating dock with a lifting capacity of 10,000 tons has recently been completed at a cost of a million dollars and installed at the Port of Jacksonville, Florida, U.S.A., for use in connection with repairs to ships of the United States Navy. It is constructed of Oregon fir, reinforced by structural steel, and was built in a basin, which was flooded on completion of the work. All the pumping machinery of the dock and controls are electrically operated.

Montrose Harbour Repairs.

At a recent meeting of the Montrose Harbour Board, ex-Bailie J. M. Piggins, convener of the Harbour Committee, reported that consideration had been given to the question of setting aside a certain sum for deferred repairs. They would be unable to spend any money on maintenance at the present time, owing to the difficulty of getting material and labour, but it was thought it would be wise to set aside a sum annually for the work to be done later. By doing so, they would be relieved of the payment of some Income Tax. The matter would be brought up again at next meeting, when they would have the estimates for the next financial year before them.

Removal of Waterloo Temporary Bridge.

The temporary structure across the River Thames which has been in use for several years since the old Waterloo Bridge was condemned as unsafe, and during the building of the new bridge, is to be removed.

Cape Town New Graving Dock.

The first pile for the new graving dock at Cape Town has recently been driven by Mr. F. C. Sturrock, Minister for Railways and Harbours, in the Union of South Africa. The dock is to be about 1,200-ft. long and 750-ft. wide.

Retirement of Harbour Engineer.

Mr. T. Shirley Hawkins, O.B.E., M.Inst.C.E., Harbour Engineer at the Ministry of War Transport and Acting Conservator of the River Mersey, has retired, and has been succeeded by Mr. C. W. Carter, M.Inst.C.E., formerly Port Traffic Manager and Engineer at the Port of Lagos, Nigeria.

Projected Deepening of Dortmund-Ems Canal.

It is announced that the Dortmund-Ems Canal is to be deepened throughout its length so as to be suitable for ships of 1,500 tons. At present, the Canal is navigable from Ems to Wanne by ships up to 1,200 tons, and from Wanne to Dortmund by vessels of 900 tons.

Dry Dock Company's Accounts.

The report for 1942 of the Mercantile Dry Dock Co., Ltd., Jarrow, shows that the company's operations, after making provision for depreciation and taxation, have resulted in a net profit of £7,009 (compared with £7,709 for 1941), to which is added the balance of £5,679 (£6,362) from the previous year, making a total of £12,688 (£14,071). The directors recommended a dividend of 7 per cent. (8 per cent.), less tax, and the carrying forward of the balance of £6,388. A year ago there was a transfer of £1,000 to the employees' benefit fund.

Belfast Dockers' Strike.

At the beginning of the month, a serious strike broke out in Belfast over a wages dispute. It started among the carters of the city, but spread to the dockers who came out in sympathy with the strikers. Labour at the docks had to be performed by the military, who were engaged in handling essential goods traffic. After some days a settlement was effected and the strikers resumed work after causing a senseless and needless interruption in the work of the port.

Port Traffic at Fayal.

Commercial maritime traffic at the Port of Horta, Fayal, in the Azores, in 1942, totalled 79 vessels, of 244,916 tons gross, in addition to the arrival and departure of 57 United States aircraft. Divided according to the vessels' national flags, the movement of shipping was as follows: British, 22 vessels (of 55,506 tons gross); Argentine, 1 (2,569); Spanish, 1 (2,845); Greek, 2 (10,753); Dutch, 1 (624); Honduran, 1 (5,221); Norwegian, 1 (3,025); Portuguese, 50 (164,373).

Galway Port Finances.

The Assistant Secretary of the Eire Department of Industry and Commerce in Dublin has been interviewed by a deputation from the Galway Harbour Board, the Galway Corporation, the County Council and the Chamber of Commerce with a view to securing for the port a share in the shipping traffic to Irish ports. There has been a serious falling-off in shipping visiting the port, the income of which has shrunk from about £6,000 a year to "almost nothing." It was pointed out that the port had handling facilities for all classes of cargo except grain. In the present strained position of the port finances, unemployment among the dock workers will become inevitable.

Earth Pressures and Sheet Piling*

By S. PACKSHAW, B.Sc., M.Inst.C.E.

A pile can be defined as a column formed in the ground for the purpose of transmitting axial or lateral loads to the subsoil; in either case the pile may be vertical or at an inclination. There are two main groups of piles: bearing piles, which are used to sustain a structure by transferring its weight to the subsoil, and sheet piles, which are driven adjacent to one another to form a continuous wall for resisting lateral pressures. These can be caused either by water, as in coffer-dams, or by earth or similar material, as in retaining walls, and from designer's point of view they represent two extremes: water pressures can be calculated with almost 100% accuracy, whilst earth pressures frequently do not amount to much more than what one hopes is an intelligent guess. The main purpose of the present paper is to consider lateral earth pressures and to review the application of sheet piling to various types of civil engineering work.

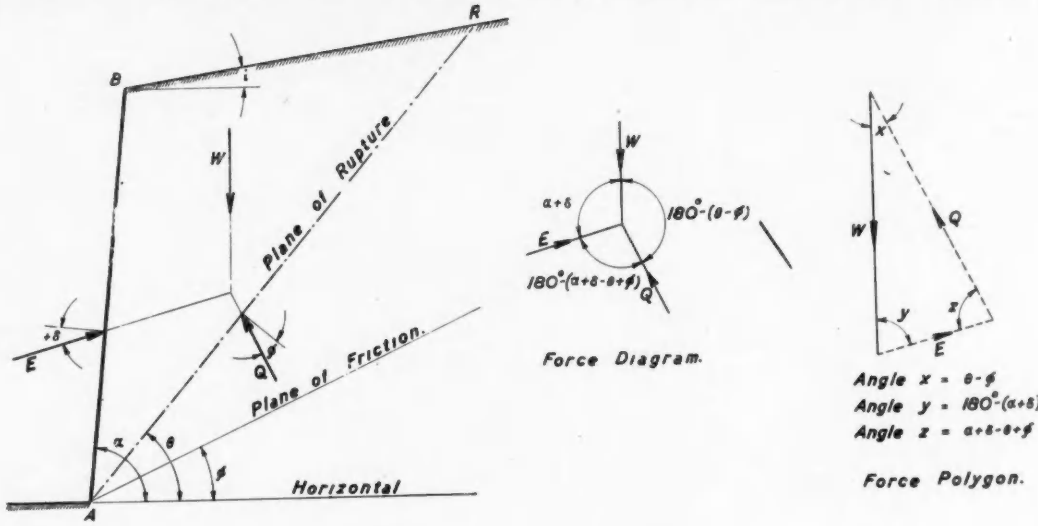


Fig. 1. Coulomb Earth Wedge.

Classical Earth Pressure Theories

The pressure exerted by the soil on a retaining wall was one of the earliest pre-occupations of civil engineers. Theories for determining such pressures date back to Coulomb (1773) whose methods are still widely applied. The names of François, Poncelet, Rebhann and Rankine are among those of many engineers and scientists who have investigated this old yet still imperfectly understood subject.

The so-called classical earth pressure theories that were developed mainly during the 18th and 19th centuries can be divided into two main categories, based on the following assumptions:

i. That the soil follows the laws governing the distribution of stress in elastic solids (e.g., Rankine's theory).

ii. That an unstable wedge of soil forms behind the wall (e.g., Coulomb's theory).

Experience has shown that the classical theories approximate closely to the actual pressures exerted on a retaining wall only in certain well-defined, though very limited, circumstances. This has been confirmed by tests on a large scale and research based on soil mechanics, though the progress made in this new science is not yet sufficient to permit the classical theories to be dispensed with altogether in the majority of cases. It has lately become the fashion to discredit the classical theories by pointing, for instance, to the fact that they do not provide for the case of a vertical face of earth standing up without any support. An understanding of the principles from which these theories are derived will, however, show whether they are applicable to the particular circumstances that the designer has under consideration.

The Rankine theory assumes that the soil consists of cohesionless particles forming an earth mass with the same properties as a homogeneous elastic solid. The stresses within the soil are therefore caused by its own weight, plus any external loads such as superloads, and the earth pressure is derived from the minor principal stress acting parallel to the ground surface. In his well-known formula, Rankine refers to the "angle of repose," which is approximately the inclination of a loosely-deposited heap of sand or other cohesionless material. This term is, however, misleading and should always be visualised as the angle of friction between adjacent particles.

For a vertical wall with horizontal ground surface and no superload, the intensity of pressure at a depth H according to Rankine is

$$p = wH \cdot \frac{1 - \sin\phi}{1 + \sin\phi} = wH \tan^2\left(45° - \frac{\phi}{2}\right)$$

or simply p = w H K, w being the density of the soil. As the pressure is thus proportional to the depth, the total pressure at a depth H is

$$E = \tfrac{1}{2}wH^2K.$$

Coulomb assumed that the pressure on the wall is derived from an unstable wedge of rupture ABR, which forms behind the wall and tends to slide down the plane AR, as in Fig. 1. This is termed the plane of rupture, or critical plane, and it develops at such an angle θ to the horizontal that the pressure on the wall is a maximum. In other words, a wedge at an angle flatter than θ would exert less pressure on the wall, as it would be more stable even though its weight were greater; whilst a wedge at a steeper angle would be lighter and thus also affect the wall to a lesser extent. The three forces acting on the wedge are its own weight, the pressure on the wall and the reaction along the rupture plane. For equilibrium, these three forces must meet at a point; when the wall is vertical, the ground surface horizontal and the wedge develops no friction in sliding down the wall, the results of the Coulomb formula are identical with the Rankine formula, which

*Paper read before the Northern Ireland Association of the Institution of Civil Engineers and reproduced by permission.

Earth Pressures and Sheet Piling—continued

is then fairly reliable; it is not accurate when wall friction is considered, or if there are other departures from its basic principles, such as a battered wall or a surcharged slope. The Coulomb method should then be used; some of the more important assumptions from which it is derived are that the rupture surface is a plane, that the total pressure increases as the square of the depth, and that the wedge behaves as if it were a solid: no account is taken of any deformations which must occur in the wedge when a retaining wall deflects or moves forward as a result of the pressure behind it.

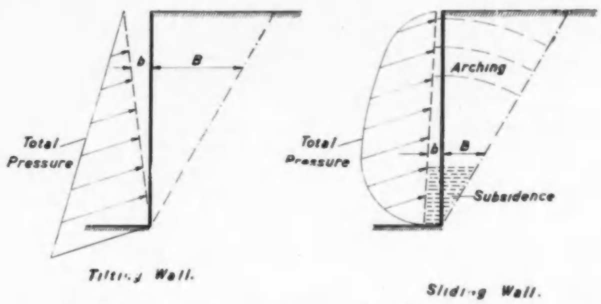


Fig. 2. Relation between Earth Pressure and Wall Movement.

The full Coulomb formula, allowing for ground inclination, wall batter and wall friction, is very cumbersome; if all or most of these factors are to be included a graphical method or tables are preferable. It can, however, also be written in the form $E = \frac{1}{2}wH^2K$. Although Coulomb determined only the total pressure and not the intensity of pressure, his formula has generally been taken to imply that the pressure is directly proportional to the depth, i.e., the distribution is hydrostatic or triangular. Such an assumption is by no means always justified.

Tests on Retaining Walls

To determine the validity of the classical earth pressure theories, it is necessary to examine the tests carried out for that purpose by Terzaghi and other investigators. In Terzaghi's very comprehensive series of experiments, dry cohesionless sand was used in a loose, and alternatively in a compacted, state. Realising that the form of wall movement, or deflection, is likely to have an important effect on the magnitude and point of application of earth pressure, Terzaghi conducted one set of tests with a wall tilting about its base and another with a wall moving forward bodily. The height of the wall was 5-ft.

The results, illustrated in Fig. 3, show that for a tilting wall the Coulomb theory is in reasonable agreement with the tests, not only as regards magnitude but also in the distribution of the pressure, provided an average movement of about 0.001H is allowed to take place. Further movement has little effect on the pressure. With a sliding wall, the earth pressure is much the same but the point of application is higher: instead of being at $\frac{1}{3}$H above the base of the wall it is nearer to $\frac{1}{2}$H. Terzaghi explains this by assuming that the sliding wedge must expand laterally in proportion to its width, this condition being satisfied by a wall tilting about its base as in Fig. 2. For any other form of wall movement the space vacated by the wall is relatively too large at the bottom and too small at the top. Subsidence therefore occurs between the rupture plane and the bottom of the wall, whilst at the top the soil tends to arch between the wall and the plane. This causes a redistribution of pressure without affecting its magnitude.

Similar tests were carried out in Great Britain by Professor Jenkin, who obtained very consistent results with a model wall only 3-in. high, using Leighton Buzzard sand. Several other investigators proceeded on the same lines. All these researches were, however, concerned with rigid walls; Terzaghi, in particular, took special care to reduce the distortion of the wall to a minimum, realising that even a few thousandths of an inch would influence the pressure distribution considerably. The relation between the pressure and the flexibility of a wall was the subject of experiments by Stroyer, who had in mind thin reinforced concrete or sheet pile walls. By a reasoning differing a little from that in the preceding paragraph, he also arrives at the conclusion that when the wall can tilt forward about its base (for instance as a cantilever sheet pile wall), the pressure will increase uniformly from top to bottom; if, however, the wall is restrained at the top (as an anchored sheet pile wall) there will be a redistribution of pressure without an alteration to its total magnitude. To verify these conclusions Stroyer carried out tests on steel plates about $\frac{1}{8}$-in. to $\frac{1}{4}$-in. thick and 3-ft. high, subjected to the pressure of sand and other dry non-cohesive materials. He measured the bending moment induced in the plate rather than the pressure, as this is of more direct value in the design of sheet pile walls; one is almost directly proportional to the other. The results showed a reduction of up to one half in the theoretical bending moment calculated from the Rankine formula.

All the experimental work described above was carried out with sand or similar cohesionless material having an angle of repose (or, more precisely, angle of internal friction) of about 30° to 35°. This angle varies little with the size or sharpness of the grains and is practically unaffected if the material is damp or immersed in water; it does, however, increase when densely compacted. From the tests one can conclude that the classical formulæ are applicable to sand and similar materials, though the distribution of pressure on anchored flexible walls shows a concentration of pressure at the supports and a consequent reduction in bending moment.

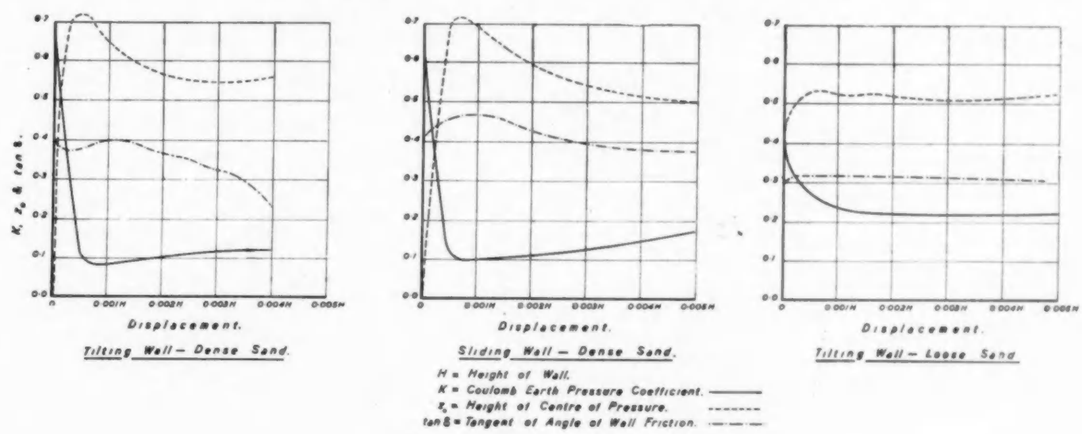


Fig. 3. Terzaghi's Tests on Retaining Walls.

Earth Pressures and Sheet Piling—continued

Cohesive Soils

Most of the soils that the engineer has to deal with are not, however, free from cohesion. More often than not the sandpaper effect of friction between grains is accompanied by the flypaper effect of adhesion. The former is proportional to the pressure between grains, but the latter is not; thus the total shear strength of

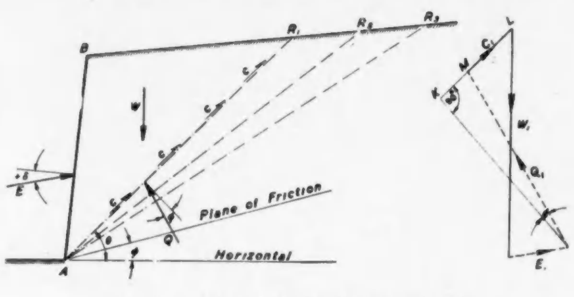


Fig. 4. Earth Wedge in Cohesive Soil.

the soil can be represented by the equation

$$f_s = f_n \tan \phi + c$$

where f_s and f_n are the shear stress and the normal stress in the soil, ϕ the angle of friction and c the co-efficient of cohesion. The determination of ϕ and c will be considered later; meanwhile it will be obvious that formulæ which do not take account of c are useless for calculating the pressure of cohesive soils. To try and overcome this disability, Bell, Fellenius and others produced a modification of the Rankine formula which gives the total pressure on a retaining wall of height H:

$$E = \tfrac{1}{2}wH^2 \tan^2\left(45^\circ - \frac{\phi}{2}\right) - 2cH \tan\left(45^\circ - \frac{\phi}{2}\right)$$

It will be seen that the first term of this equation is the same as the original Rankine equation.

This explains the well-known phenomenon of a vertical face of earth standing up without support provided the critical height is not exceeded.

The modified Rankine formula applies to the simplest case of a vertical wall, horizontal ground surface, no super-load and no wall friction. A more general solution can be obtained graphically on the Coulomb principle by the method of trial wedges shown in Fig. 4. The forces acting on the first wedge such as ABR_1 are its weight W, known in magnitude and direction; the earth pressure E, known in direction only when the value of the wall friction δ has been assumed; the reaction Q_1 known in direction only, acting at an angle ϕ from the normal to the rupture plane AR_1; and the total cohesion $C_1 = c.AR_1$, known in magnitude and direction. Moreover, W_1 must act through the centre of gravity of the wedge, whilst C_1 is concentrated along AR_1. This settles the point of inter-section of W_1 and C_1; the resultant of the other two forces must pass through the same point if equilibrium is to be maintained, but it does not follow that E_1 and Q_1 will then act at the third points above A and thus comply with the requirements of the classical theories.

A polygon of forces can then be drawn to determine E_1 and the process repeated for various inclinations of the rupture plane until E_{max} is found. In the polygon, the line KL represents the total shear strength and is composed of the frictional part KM and the cohesion ML; thus the polygon can still be drawn, even if the total shear strength has not been split up into its constituents and only the total is known.

Experience based on the failure of retaining walls and embankments or cuttings has shown that the rupture surface is not a plane, particularly in cohesive soils. Recent theories developed by Fellenius, Odhe and others assume that the rupture surface is circular; Terzaghi takes it to be a logarithmic spiral. The pressures obtained from these theories are not, however, very different from Coulomb's. It is only when considering the stability of the wall as a whole, together with the surrounding subsoil, as distinct from the pressure on the wall, that circular slips become the basis of the problem. In such investigations, the wall and subsoil are assumed to rotate along a circular arc passing through the ground some distance below the foot of the wall.

Cohesive soils are unstable in comparison with sandy materials

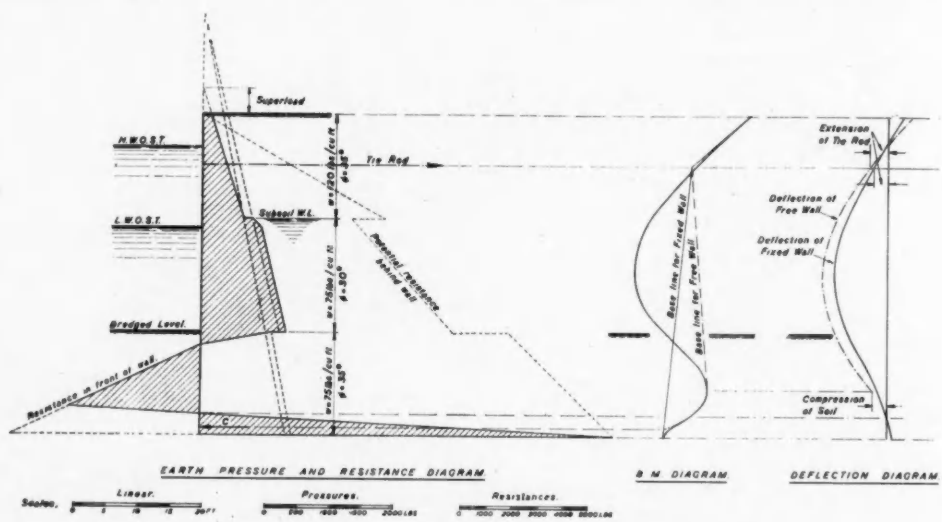


Fig. 5. Typical diagrams for Sheet Pile Walls.

A simple derivation of this formula is obtained by equating E to zero. One then obtains the height H_c at which there is no earth pressure on the wall:

$$H_c = \frac{4c}{w} \cot\left(45^\circ - \frac{\phi}{2}\right).$$

and their properties change considerably under the influence of various factors, particularly the moisture content. For that reason, few, if any, experimental determinations of pressures on retaining walls have been made. Thus the designer has no means of checking the validity of the numerous assumptions he is compelled to make. It seems probable, however, that the distribution of pressure on the wall will again be affected by the manner in

Earth Pressures and Sheet Piling—continued

which the wall moves or deflects, and that the bending moment in a sheet pile wall will be less than in a rigid wall. It is also likely that the effect of wall movements will diminish with the angle of friction and the cohesion, so that the reduction in bending movement will be least with soft clays possessing little cohesion and negligible internal friction.

Earth Pressure Diagrams

Mass concrete or reinforced concrete walls have to be built so that there is some depth of soil in front of them; this can then develop earth resistance when the wall tends to move forward due to the earth pressure behind it. The determination of earth resistance is particularly important in the design of a sheet pile wall which acts as a vertical beam driven into the ground. As a rule the piling is supported by tie rods at the top so that the wall spans from the tie rod down to some point below ground level. In either case the earth resistance has an important effect on the length and strength of the sheeting.

The resistance of the soil can be calculated from classical formulæ, such as Rankine's, which have been developed for that purpose, or later variations which attempt to introduce cohesion. The principles are much the same as for earth pressures though there are many uncertain factors—for instance, the relation between the compression of the soil as a result of the piling deflecting into it, and the resistance developed by the soil. A discussion of these aspects of design is, however, outside the scope of this lecture.

A typical earth pressure and earth resistance diagram for sandy soil is shown in Fig. 5. The pressure is calculated from the Rankine formula and is assumed to increase uniformly with the depth; the break in the line is due to the change in the value of ϕ and the reduction in density of the submerged soil. On the resistance side the theoretical resistance has been multiplied by a factor of 2, to allow for the effect of wall friction which increases the resistance to much more than the Rankine value, when ϕ is 30° or more. This is quite common practice. Two alternative base lines are shown for the bending moment diagram, as the equilibrium of the wall can be secured in two ways: in the first, the depth of penetration is just sufficient to ensure stability, and the wall then acts as a simply supported beam; in the second, the penetration is large enough not only to support the piling, but also to provide a fixing moment, so that the wall becomes a vertical cantilever held by the tie rod near the top. To obtain the fixing moment, the piling must develop earth resistance both in front and behind, and must, therefore, be sufficiently flexible to deflect first forwards and then backwards. Timber and reinforced concrete sheet pile walls, being relatively stiff, are designed on the first alternative; for steel sheet piling, the second is generally chosen. It results in longer piles, but a smaller bending moment, and automatically ensures a proper factor of safety, as the wall cannot fail until it has been overloaded to such an extent that conditions at the foot have passed from fixation to simple support.

(To be continued)

Port of Bombay

Appointment of General Manager, Docks and Railway

On the recommendation of the Finance and General Committee, the Board of Bombay Port Trustees have sanctioned the proposal of the Chairman that a temporary post of General Manager, Docks and Railway, be created only for the duration of the War, to assist the Chairman generally in the daily administration of the Docks and Railway and to secure close co-ordination between the two departments which deal with the cargo shipped to and from Bombay. The creation of the post has been necessitated by the unprecedented strain on the Dock and Railway Departments since the fall of Singapore and Rangoon and by the heavy new responsibilities imposed on the Administration owing to recent War developments. Among the principal duties of the officer will be

(a) to investigate and prepare schemes for improvement of port and railway facilities;
(b) to secure effective co-ordination between the Railways, the Military Authorities, the Navy, the Ministry of War Transport and the Port Trust Administration;
(c) to deal generally with all problems relating to the quicker, turn-round of shipping and wagons; and
(d) to make arrangements to ensure the functioning of the docks and railway in emergencies arising from hostile raids, etc.

The Bombay Port Trust Act provides for the appointment of a Deputy Chairman from time to time, but in view of the nature of the duties to be attached to the post, the Finance and General Committee agreed with the Chairman that the designation General Manager, Docks and Railway, would be more appropriate.

Since no Indian with combined experience of both docks and railways was available, the Chairman recommended that Col. J. R. Sadler, C.B.E., R.E., be appointed to the post. Col. Sadler, before the beginning of the War had extensive experience for over 20 years of railway and dock administration in England. In 1939 he was appointed Director of Docks, British Expeditionary Force, France. In the following year he was transferred to the Middle East as Director of Docks and Inland Water Transport to the Egyptian, Libyan and Palestinean Forces. Since July, 1942, he has been Assistant Director of Transportation, Bombay, and as such has had special opportunities of studying the dock, railway and labour problems relating to the Bombay Port.

South African Port Development

Ministerial Statement

The following are extracts from a statement made to the *Cape Times* recently by Mr. **F. C. Sturrock,** the Union Minister of Railways and Harbours:—

"Work on Cape Town's harbour, and at other Union ports, is proceeding with all the expedition possible and there has been no slowing up as a result of the alteration in the strategic position following the North African operations.

"It is possible that there will be a slackening off in the amount of shipping using South African harbours compared with that of recent months, but this need not be taken as indicating that there will be many idle moments for us. Although our harbours are not overloaded as they have been in the past they will be working to full capacity.

"At Cape Town, the new Duncan Basin is virtually completed and already in operation. Work on the new graving dock is proceeding satisfactorily; so far as South Africa's part of the work is concerned we are up to our time schedule. The oversea part of the work, which mainly concerns the caissons, gates, and pumping machinery, is all in hand in Britain and no delay in the delivery of these is anticipated.

"The Administration's harbour development is, of course, not confined to Cape Town. We are providing a dry dock at East London, floating docks at Port Elizabeth and Durban, and extra quayage at all these harbours.

"The time has now been reached when all the necessary planning for the post-war development of Cape Town's foreshore will have to be proceeded with. It will not do to await the end of war before preparing our plans, otherwise, when that times comes there will be much unnecessary delay.

"It is no easy matter to forecast the prospects of our harbours after the war; a good deal depends on the nature of the peace settlements, on the encouragement given to the free flow of trade to the different parts of the world, or how far the passenger and tourist traffic will develop, and on the nature of the naval problem in the post-war world.

"I am, however, on the whole, optimistic, and I believe that although we have developed Cape Town harbour beyond what we have hitherto envisaged as its peace-time potential, I firmly believe that after the war trade will develop to the full capacity of our ports.

Public Belt Railroad Diesel Electric Locomotives pulling a freight train over the Mississippi River Bridge.

New Orleans (U.S.A.) Public Belt Railroad*

A Notable American Port Service Line

THE New Orleans Public Belt Railroad is unique among the railroads of the United States in that it is a publicly owned and operated Terminal Switching Railroad, the property of the City of New Orleans and operated through a Commission known as the " Public Belt Railroad Commission."

Since it is a publicly owned and operated utility, the Public Belt Railroad is particularly fortunate in that its founders took every precaution to guard against political influence and the domination of political parties and patronage in the enabling act and legislation establishing this Commission.

Organisation

The Public Belt Railroad Commission is composed of the Mayor of the City of New Orleans, who is, by virtue of his office, president of the Commission, and sixteen taxpayers, eleven of whom are appointed under the law by the Mayor upon the recommendation of, and from, the membership of each of the several organisations, such as the New Orleans Association of Commerce, New Orleans Board of Trade, Louisiana Sugar and Rice Exchange, New Orleans Cotton Exchange, etc., and five from the citizens of New Orleans at large, who also are appointed by the Mayor.

The members of the Commission are appointed for terms of sixteen years, two terms of membership expiring every two years.

It will be noted that those public bodies which are charged with the election of members to the Belt Commission are vitally interested in the business of the Port of New Orleans and consequently are very careful to select their best men for service on the Public Belt Commission. These man serve without pay and give freely of their time and efforts to assist in the improvement and extension of the Public Belt service where it will benefit the City and the Port.

With such an organisation and men serving such long terms, selected rather for their business ability than through any political reason, the Public Belt Railroad Commission is remarkably free from the politics which frequently dominate other public utilities.

As President of the Commission, the Mayor has a right to vote at all meetings and upon all questions.

The active head of the Commission is its president *pro tem* who is elected by the Commission from that part of the membership appointed by the industrial organisations; subject to its direction, he has active charge of the control, management and supervision of the business of the Commission.

Acting generally under the policy laid down by the Commission through its president *pro tem*, the General Manager, appointed by the Commission, operates the railroad and has the same duties and responsibilities as the General Manager of any trunk line railroad.

The Secretary-Treasurer, also appointed by the Commission, is responsible for all the accounts, records, etc., of the Commission.

The departmental organisation of the Public Belt Railroad is practically the same as any other railroad, omitting, of course, the passenger feature.

Unification of Facilities

At the commencement of the labours of the Commission, there were as many sections of track serving the waterfront as there were railroads entering the city. The switching system was cumbersome, causing heavy delays in movement, which amounted almost to prohibition. There was necessarily a multiplicity of switching and duplication of service and consequent pyramiding of charges.

The Belt Railroad has unified the service along the city front, rendering the rail and water facilities available to all on equal basis. The railroad and steamship lines and the public generally have been measurably benefited thereby. And the operation of the Public Belt Railroad system has been the means of greatly reducing terminal charges at the Port of New Orleans.

Public Belt Railroad Self Sustaining

The Belt Railroad has been self-sustaining from the inception of its operation. The Public Belt Railroad Commission does not derive any revenue from any cources of taxation whatsoever.

* Reproduced from *New Orleans Port Record*, January, 1943.

New Orleans (U.S.A.) Public Belt Railroad—continued

Physical Properties

Under above-mentioned organisation the physical properties of the Belt have grown from its original 20 track miles and one locomotive at the beginning of its operation in 1908 to a system of 118 miles, composed of 22 miles of double main track and 74 miles of yard tracks and sidings, including fifteen public delivery (team) tracks scattered over the system, affording quick delivery therefrom to any and every part of the City. The Public Belt Railroad serves the entire River Front and the Industrial Canal with their eight miles of publicly owned docks and wharves, where normally large volumes of commerce are constantly being interchanged with Inland Water Carriers, and with nearly a hundred steamship lines calling at all important world ports. It also serves several hundred industries and plants in the large industrial area, including the Public Cotton Warehouses, Public Grain Elevator, Delta Shipyards, etc., as well as its five-and-a-half-mile Mississippi River Bridge which crosses the river at a point about three-and-a-half-miles above the City, and which serves to connect the east side and west side railroad lines without the use of ferries by which this crossing was formerly effected.

The Public Belt's Mississippi River Bridge is one of the longest, if not the longest, steel railroad bridge in the United States (4.36 miles abutment to abutment). It consists of steel trestle approach of 1.65 miles on the east side of the river, 2.05 miles on the west side of the river, crosses the river proper a distance of .66 miles on one cantilever span, 790-ft. with anchor spans of 529-ft. and 531-ft., one through span of 531-ft. and four deck spans having a total length of 1,144-ft.

The bridge, which is a double track structure, also carries a vehicular roadway cantilevered to each side of the approaches and span.

The total cost of the bridge, which was constructed in 1932-1935, was approximately $13,000,000.00. Due to the construction of the highway in connection with the bridge and approaches, half of the expense was borne by the State of Louisiana which in this way established a toll-free highway crossing. The bridge is owned, operated and maintained by the Public Belt Railroad. Presently the Texas and New Orleans Railroad (Southern Pacific), Texas and Pacific Railway, Missouri Pacific Railroad and Texas Pacific-Missouri Pacific Terminal Railroad of New Orleans operate across the bridge and on the tracks of the Public Belt under contract.

Mr. EDMUND J. GARLAND.
General Manager of the New Orleans Public Belt Railroad.

The Public Belt Railroad equipment consists of 27 cars which are used only in intra-terminal switching service and 19 locomotives of which three are Diesel Electric 900 h.p. and three are Diesel Electric 660 h.p., and thirteen steam locomotives of which ten are fuelled with oil and three with coal. This equipment is maintained and rebuilt in modern shop facilities constructed in 1925 and equipped with all the necessary machinery and tools to make complete repairs to both its steam and Diesel electric locomotives.

With the large number of foreign cars arriving on the Public Belt Railroad, it is necessary to maintain quite extensive car repair shops in which all necessary repairs are expeditiously made. Approximately 1,800 cars per month are repaired on the main car repair tracks and one sub-station.

The car repair plant is equipped to make all necessary repairs to freight cars and for the replacement of wheels and axles, air-brake repairs, carpentry and iron work.

Operation

The Public Belt connects directly with all railroads entering the City and affords rapid transportation for cars from inter-change to inter-change and from inter-change to destination at docks, grain elevators, cotton warehouses and private industries.

Normally, all cars received from connecting lines by 7 p.m. are placed for unloading by 7 a.m. the following morning. And cars received after 7 p.m. are placed for unloading by the following noon hour. Also cars loaded in New Orleans at docks and industries during the day depart from New Orleans on line-haul trains prior to midnight of the same day. Operating as it does largely in the congested river front district, this class of service calls for the highest efficiency in all departments.

The Transportation Department is headed by the Superintendent of Transportation with a day and night General Yardmaster and four yardmasters. Between 800 and 1,000 cars per day are handled by the Public Belt.

The track is well designed and maintained by the Engineering Department, rail being 80 pounds, 90 pounds, and 110 pounds as required by the traffic. The road is divided into six sections, each having a foreman and from 10 to 14 men. The 113 railroad grade crossings and something over 500 turnouts require full time use of a welding unit composed of two men equipped with both electric and acetylene welding.

The Maintenance of Way equipment consists of weed cutting, bolt wrenching machines, rail joint oiling machines and, of course, section motor cars.

The Traffic Department, under the guidance of the Traffic Research Counsel-Traffic Representative, functions in virtually the same manner as traffic departments of other railroads. Its principal duties are the promotion of industrial development on the line and the solicitation and development of commerce to, from and through the City and Port of New Orleans in connection with the Belt.

The Belt, being a common carrier subject to the Interstate Commerce Act, publishes and files its tariffs of rates and charges with the Interstate Commerce Commission. The Belt's switching charges are absorbed by its rail connections on road-haul competitive shipments and on certain non-competitive traffic. Also the Federal and Mississippi Valley Barge Lines absorb the Belt's switching charges.

The Accounting Department is sub-divided into Car Accounting and General Accounting. Under the Car Accounting Department comes all the accounts connected with the handling of cars from the time they arrive on the interchange until they depart from the Public Belt track.

The Public Belt Railroad is a member of the Association of American Railroads and is operated strictly under the A.A.R. rules as to car accounting, routing per diem, etc., and has been cited by the Car Service Bureau as an example of efficiency in the proper handling of cars, and car accounting.

The general accounts are handled in conformity with the rules and regulations of the Interstate Commerce Commission, the same as on any other railroad with one exception, i.e., since it is a department of the City of New Orleans and subject to possible criticism which applies to all public bodies, a monthly audit of its accounts is made by a nationally known firm of certified public accountants, in addition to the more infrequent audit of the Bureau of Accounts of the Interstate Commerce Commission.

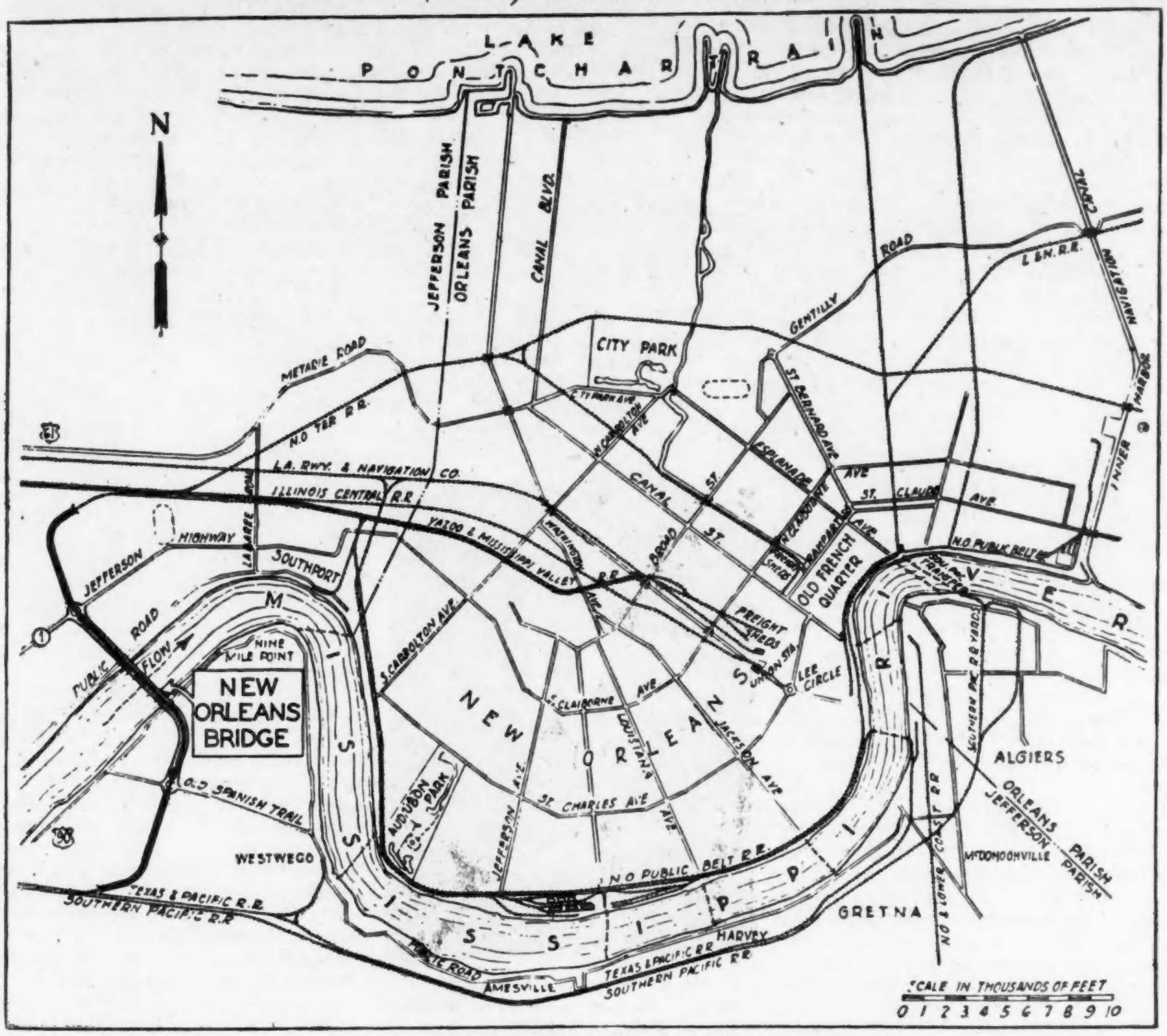
Presently there are 504 employees on the pay rolls of the Public Belt Railroad, 364 of which are white and 140 are coloured. Approximately 90% of these employees subscribed to the pay roll deduction plan for the purchase of War Bonds.

The Public Belt monthly pay roll approximates $79,000.00.

Financing

The Public Belt Railroad began active operation in August, 1908. The City of New Orleans through its Council made a total appropriation in cash of $486,264.42 for the construction of the Public Belt Railroad during the years 1905 to 1911. As time went on the Belt Railroad expanded and in 1912 the Belt Commission issued its first bonds, which were authorised under Act 179 of 1908. Under the provisions of this Act the City of New Orleans was authorised to issue $2,000,000.00 of bonds for Public

New Orleans (U.S.A.) Public Belt Railroad—continued



Map of the New Orleans Public Belt Railroad.

Belt Railroad purposes. These bonds were issued in four series, namely: $300,000.00 in July, 1912; $500,000.00 in June, 1915; $600,000.00 in December, 1919, and $600,000.00 in October, 1923. Under the provisions of this Act No. 179 these bonds were redeemable at the rate of $100,000.00 per annum, beginning the year 1939.

In July, 1928, the Belt Commission issued $1,000,000.00 of bonds of the $5,000,000.00, authorised under the Constitution of 1921, the proceeds of which were used for the purchase of lands in connection with right-of-way to the Bridge and other lands and for Additions and Betterments to the railroad.

In 1928, Act No. 154, being an amendment to Section 28, Article XIV of the Constitution of 1921, was adopted by the Legislature of Louisiana. Under the provisions of this Act the City of New Orleans was authorised upon the recommendation of the Public Belt Railroad Commission, to issue bonds not to exceed $20,000,000.00 in lieu of $15,000,000.00 authorised by the Constitution, for the purpose of constructing the Mississippi River Bridge. Pursuant to provisions of this Act No. 154 the City of New Orleans through the Public Belt issued $6,000,000.00 of bonds in 1932 for the purpose of constructing the Mississippi River Bridge and the State of Louisiana through the Highway Commission issued $7,000,000.00 of bonds to cover its proportion of the cost of the bridge. These bonds were issued by the State in order to provide toll free to vehicles and pedestrians the highway section of the Mississippi River Bridge.

Of the $6,000,000.00 bonds issued by the Public Belt in 1932 for bridge purposes, $2,232,000.00 have been retired, leaving a balance outstanding of $3,768,000.00 as of October 31st, 1942.

The original $6,000,000.00 Bridge bond issued was sold to the Reconstruction Finance Corporation at an interest rate of 5%, in 1932. During the year 1936 these bonds were refinanced and sold to private bankers at an interest rate of 4%, resulting in a saving to the Belt Railroad of $465,000.00 in bond interest.

Under the provisions of the contract for the use of the bridge, the principal and interest on the bridge bonds will be amortized from rentals received from the Texas and New Orleans Railroad.

In October, 1937, the Public Belt Railroad Commission issued $500,000.00 of bonds under authority of the Constitution of 1921. These bonds were issued for the purchase of Diesel electric locomotives and other purposes.

Under Act No. 45 of 1938, the City of New Orleans is authorised to issue upon recommendation of the Public Belt Railroad Commission $2,000,000.00 of bonds for the purpose of refunding or retiring the $2,000,000.00 of bonds previously issued under Act No. 179.

The $2,000,000.00 of bonds authorised by Act 45, above referred to, have been sold at an interest rate of 3.0135 % and the avails from this bond issue were used on July 1st, 1939, to retire the $2,000,000.00—5% bonds issued under Act 179 of 1908, resulting in an interest saving of approximately $40,000.00 per year.

Summarised, the total bonded indebtedness of the Public Belt Railroad Commission on October 31st, 1942, including the bridge bonds, was $7,268,000.00.

The investment value as of October 31st, 1942, of the New Orleans Public Belt Railroad, including the Mississippi River Bridge, was $17,603,216.52.

Ship Caissons for Dock Entrances

An Article for Students and Junior Engineers

By STANLEY C. BAILEY, Assoc.M.Inst.C.E., F.G.S.

SHIP or floating caissons for closing the entrances to dry docks and, less frequently, to wet docks or basins, are also used for dividing a long graving dock into two or three lengths, by placing them in suitable grooves, similar to that at the main entrance, and are situated about half or one-third of the way down the length of the dock, so that shorter ships may be docked, in the smaller compartments and the amount of pumping reduced. They may also be used for extending the available length of a dry dock for longer ships than the dock proper will take, by placing the entrance caisson in the outer groove or stop which is usually situated some distance outside the entrance groove.

Should the entrance be closed by a sliding caisson or gates, then a ship caisson can be placed in the outer stop to enable repairs or painting to be carried out on the sliding caisson or gates in the dry, so that in Ports where there are a number of docks with entrances of similar size, it is advisable to provide a spare ship caisson for emergency purposes.

They are not so expensive as gates or sliding caissons for equal entrance areas, and the latter need special machinery to operate them, but whereas these can be opened or closed in a few minutes, ship caissons require from 15 to 20 minutes.

The floor of a dry dock is usually from 3 to 4-ft. below the cill level at the entrance, so that the intermediate caisson in the dock is deeper than that at the entrance, but occasionally cills are formed at the intermediate points, having the same level as the entrance cill, in which case the caissons are interchangeable.

If the entrance passage to a dock is sufficiently long, which is advisable, so that a ship can be trained in alignment with the entrance, a recess may be formed on one side clear of the outer stops so that the caisson can be berthed in it clear of the fairway, bollards and ring bolts being provided on each end of the caisson and also at each end of the recess for securing the caisson, while power capstans and fairleads will be required on each side of the entrance to operate the caisson.

Should the entrance passage be short, then the recess may be formed in the walls outside it, or the caisson may be simply moored to the walls, spare caissons being similarly accommodated in wet docks.

In most ship caissons, the top deck is sufficiently wide to be used as a roadway when the caisson is in position across the entrance.

Caisson Decks and Chambers

Ship caissons have usually in common with sliding or box caissons, three decks and three chambers, viz.: the top deck used as a roadway, the upper tidal water deck, and the lower tidal water deck; between the roadway deck and the upper tidal deck, is the upper tidal chamber, and between the upper and lower tidal decks is the air chamber. while below the lower tidal deck is the lower tidal chamber.

The sea water on the outside of the caisson enters the lower water chamber either through 6-in. or 9-in. diameter holes in the outside skin plating near the bottom of the caisson, or through pipes with valves controlled from the air chamber or the top deck of the caisson, and passing through two trunks from 2-ft. 6-in. to 3-ft. diameter in the air chamber, reaches the upper tidal water chamber, which is sometimes flooded by pipes with valves worked from the top deck, the pipes usually pass through the air chamber to the skin plating on each side of the caisson; the valves are on the top deck of the air chamber.

Ventilation holes 3-in. in diameter are provided in the sides of the caisson below the roadway deck.

Two trunks or tubes are also required between the roadway deck and the top deck of the air chamber, one of which is sometimes used for the rising main from the pumps in the air chamber. Ventilation holes will be required in the upper portions of these trunks, or else 3-in. diameter vent pipes from the top deck of the air chamber to outlets in the sides of the caisson just below the roadway deck, the trunks being fitted with manhole covers at the top deck level.

Ladders or step irons should be provided in all the trunks, the rungs being 1-in. in diameter and 9-in. pitch, the sides of the ladders being 12-in. apart.

Water Tanks, Pumps and Ballast

The scuttling tanks for water ballast used for sinking the caisson across the entrance are generally placed in the air chamber in the middle of the length. They may be either rectangular or cylindrical closed tanks. If fixed at each end, and the water does not rise regularly in each, the caisson will not sink on an even keel, and may become jambed in the groove. The water to the tanks enters through valves in the floor of the air chamber and passes through intake pipes to each tank, these pipes are also connected to the pumps and to the end ballast tanks.

By means of suitably placed valves, the main inlet pipe is also used as a suction pipe, and for draining purposes from a sump in the floor of the air chamber, in case water should accumulate in it from leaks or broken pipes. The force pumps used may be driven by a Diesel oil engine or by electric motors in connection with electric mains on the wharf, or the water may be blown out of the tanks by compressed air.

The rising main from the pumps discharges either into the upper water chamber, or through the sides of the caisson above the highest tide level. At each end of the air chamber are the water ballast tanks that form part of the permanent ballast, which with the addition of the cast iron or concrete ballast in the bottom of the caisson, are used to overcome the excess buoyancy when the caisson is being floated out with 6-in. or 12-in. freeboard from the top deck of the air chamber to the water level.

The trimming tanks are generally situated in the middle of the length of the caisson, between the top deck and high water level, they are used partly for scuttling water and also for surplus ballast to prevent the caisson rising on exceptionally high tides.

They are filled wih water through a flexible hose pipe from the mains on the wharf, being emptied by pipes with valves into the upper water chamber. All tanks should be provided with 1½-in. or 2-in. diameter vent pipes to above the highest tide level.

The ballast in the bottom of the caisson may consist of 1-2-4 cement concrete weighing about 140 lbs. per cub. ft. (16 cub. ft. per ton) or concrete containing iron or steel burrs or punchings from rivet holes, weighing from 320 lbs. per cub. ft. (7 cub. ft. per ton) to 350 lbs. per cub. ft. (6.4 cub. ft. per ton) or closely packed pig iron at 284 lbs. cub. ft. (7.88 cub. ft. per ton). It is preferable to use the heavier materials, as the immersed volume will be less and so decrease the amount of buoyancy due to the water displaced by the ballast.

Weights of Caissons

The dead weight of ship caissons, exclusive of all ballast, varies between 2 cwts. per sq. ft. of entrance area from coping to cill for entrances 82-ft. by 38-ft. deep; 3 cwts. for entrances 95-ft. by 45-ft. deep; and 3.34 cwts. for 95-ft. by 55-ft. deep entrances.

No advantage is gained by cutting down the weight of the steelwork, because a lightly built caisson will be too flexible, and will deflect under the full water pressure causing the ends to open out from their bearings on the masonry, thus bringing increased pressure on the edges of the quoin stones.

The caisson should be so rigid as possible, and the lighter it is made, the more ballast will be required to sink it; for instance in the caisson shown in Figs. 1, 2 and 3, which is a modern type for an entrance 120-ft. wide at coping and 50-ft. deep to the cill, with 44-ft. depth of water at H.W.O.S.T. the walls having a batter of

Ship Caissons for Dock Entrances—continued

1 in 12, the entrance area will be 5,819 sq. ft. which at 2.5 cwts. per sq. ft. = 727 tons approximately; to float this caisson with a freeboard of 1-ft. between the top deck of the air chamber and the water level, the buoyancy being 1,042 tons will require 1,042-727 = 315 tons of water ballast, while a caisson weighing 3 cwts. per sq. ft. would weigh about 873 tons, the buoyancy being 1,048 tons, so that only 175 tons of ballast will be necessary.

To sink the lighter caisson in the entrance at H.W.O.S.T. the buoyancy will be about 1,160 tons, so that 433 tons of ballast will be required, while the heavier caisson will involve 309 tons, the buoyancy being 1,182 tons, assuming that there is no concrete ballast in the bottom.

The difference in the buoyancies is due to the amount of water displaced by the variation in the thickness of the steelwork.

It is not advisable to have a large proportion of water ballast, as this will raise the centre of gravity, so that the solid ballast in the bottom of the caisson should be increased, provided the amount does not add to the buoyancy too much by the additional volume of water displaced.

The weights of the lower decks and beams, the increased thickness of the skin plating towards the bottom, the weights of the tanks and pumps, and the asphalt covering to the lower decks, all assist in lowering the centre of gravity, which is not easy to attain in caissons, especially in those of rectangular cross section.

In the caisson illustrated by Figs. 1, 2 and 3, the weight of the timber in decking and fenders will amount to about 35 tons, or 4% of the weight of the caisson, while 1½-in. of Seyssel asphalt on the upper and lower decks of the air chamber will weigh 50 tons at 156 lbs. cub. ft. or 5.74% of the total weight, leaving 788 tons for the steelwork and paint which amounts to 18.3 lbs. of steel per cub. ft. of caisson, and $\frac{18.3}{490} = 0.037$ cub. ft. of steel per cub. ft. of caisson on the average.

The weight of rivet heads and bolts will be about 5% of the total weight.

Construction of Caissons

Figs. 1, 2 and 3 show a longitudinal section, plan, and cross section respectively for a ship caisson for an entrance 120-ft. wide, and 50-ft. deep, for the particular tidal levels given in the sketches.

The decks form the main beams with free ends, that take the full water pressures when the caisson is sunk in the entrance groove, and the dock is empty of water. The roadway deck (A) will have to sustain a lateral pressure of about 120 tons at H.W.O.S.T. and will also have to carry the live load of say 1 cwt. per sq. ft. and dead load of 75 lbs. per sq. ft. of the deck and beams, and the weight of the trimming tanks.

On the deck, B, there will be a lateral pressure of about 840 tons, and a vertical load due to 17-ft. head of water = 0.485 ton per sq. ft. × 3,165 sq. ft. = 1,535 tons; in addition there is the weight of the superstructure above it, with its live load, and the water ballast in the trimming tanks, also 1½-in. of asphalt, so that the main cross girders 10-ft. apart may have to carry so much as 180 tons, of which 146 tons will be vertical water pressure.

The lateral pressure on deck, C, will amount to about 1,418 tons, and the upward water pressure due to 30-ft. head or 0.85 ton per sq. ft. by 2,910-ft. = 2,473.5 tons.

Each main cross girder will have a load of about 45 tons from each of the two stanchions supporting deck B, and also must carry the scuttle tanks, pumps, etc., and the 1½-in. asphalt covering, so that the total downward load will be about 127 tons, and the upward water pressure of 255 tons per girder will thus be reduced to 128 tons.

The lateral pressure on the keel will be 1,044 tons, or about 9.5 tons per lin. ft. continuous bearing.

Between the keel and the decks, there are longitudinal ribs or stringers about 3-ft. apart at the bottom to 5-ft. apart at the top, to which the skin plating is riveted, the stringers being attached to vertical frames spaced 10-ft. apart; these are all beams with fixed ends, and the lateral pressures on them are transmitted to the decks by the vertical frames.

The side plating is laid with one plate overlapping 3-in. or 4-in. the one above and below it, having butt joints at the ends with cover plates; the plates should be arranged to break joints at each strake, and the edges are slightly bevelled for caulking purposes. The plates may be in lengths of 20-ft. by ⅜-in. thick at the top of the caisson and ¾-in. up to 1-in. thick at the bottom, accord- to the depth of water, and the spacing of the stringers apart. The rivets should have full heads as a provision against rust and tension, especially as there is already an initial strain on them of about 1 ton per sq. in. due to their contraction after cooling.

The use of oxy-acetylene or electric welding will save about 10% of the weight, but this is not of importance in the case of caissons.

The thickness of the plates may be calculated by the following formulæ, viz.:—

$$T = \sqrt{\frac{L^2 . D}{44800}} \qquad T = 0{\cdot}00465 L \sqrt{D}$$

which will allow a safe stress of 6.66 tons per sq. in. where T = thickness of plate in inches, L = span in inches between the stringers, and D = depth of water in feet to centre of plate.

The decks are formed of ½-in. or ⅝-in. steel plates riveted to longitudinal beams 3 to 4-ft. apart, fixed to the cross girders; these are all beams with fixed ends.

The roadway deck is given a camber in cross section of about 1-in. in 7-ft. and is covered with 3-in. or 4-in. thick longitudinal creosoted elm wood planks, or blocks laid in bitumen, with ¼-in. space between the planks or blocks, which is filled with hot bitumen.

The kerbs of the roadway are made of creosoted oak or elm, 9-in. by 4½-in. or 12-in. by 6-in., on which is fixed the galvanised forged iron or steel stanchions spaced about 5-ft. apart that support the galvanised tube hand and guard rails 1¼-in. outside diameter and ⅛-in. thickness of metal. The top and bottom decks of the air chamber are usually covered with 1-in. to 1½-in. of Seyssel asphalt applied hot, and all steel surfaces at the bottom of the caisson in contact with concrete should be coated with ⅜-in. asphalt cement, which is asphalt mixed with bitumen, boiled and applied hot.

Sluices are sometimes fitted to the sides of the caisson near the bottom to assist in levelling up the water in the dock preparatory to the removal of the caisson, or for flushing mud out of the entrance, but these functions are better performed by culverts and penstocks in the entrance walls. In the keel and stems there should be no projection of the steelwork beyond the clapping timbers, as this will cause spawling and chipping of the granite cill and quoin stones, any such projection should be covered with timber, and the outer arrises of the timber should be rounded or chamfered.

The clapping timbers of the keel and stems are usually of Demarara greenheart, or oak, with short lapped joints, fastened to the steelwork of the caisson by 1¼-in. diameter bolts, the heads of the bolts being sunk in the timber, and the holes plugged with hard wood, washers should be provided, and the bolts should be a driving fit in the timber, being staggered about 1-ft. 6-in. apart, or 3-ft. on each line of bolts. A layer of thick bitumen sheeting or strong canvas steeped in red lead should be interposed between the timber and the steelwork. Timber fenders of creosoted pitch pine or elm on the sides of the caisson will also be required as shown in the sketches, and outside ladders from the top deck of the air chamber to the roadway deck.

Small bollards will be necessary at the ends of the caisson at the top deck on each side, and ring bolts at the ends about 12-ft. above the air chamber. The caisson may be painted both inside and outside with two coats of red lead or oxide of iron paint, and two finishing coats of grey lead paint, but on account of the great liability to rusting, it is preferable to coat the steelwork with bitumastic solution and bitumastic enamel, or tar consisting of a mixture of 9 gallons of boiled gas tar to 2½ quarts naphtha, and 13 lbs. of dry slaked lime powder.

Draught figures from the keel upwards should be painted one foot apart on the stems of the caisson.

Floating Out Caissons

When the caisson is floating out, it is usual to arrange for the water level to be from 6-in. to 12-in. below the top deck of the

Ship Caissons for Dock Entrances—continued

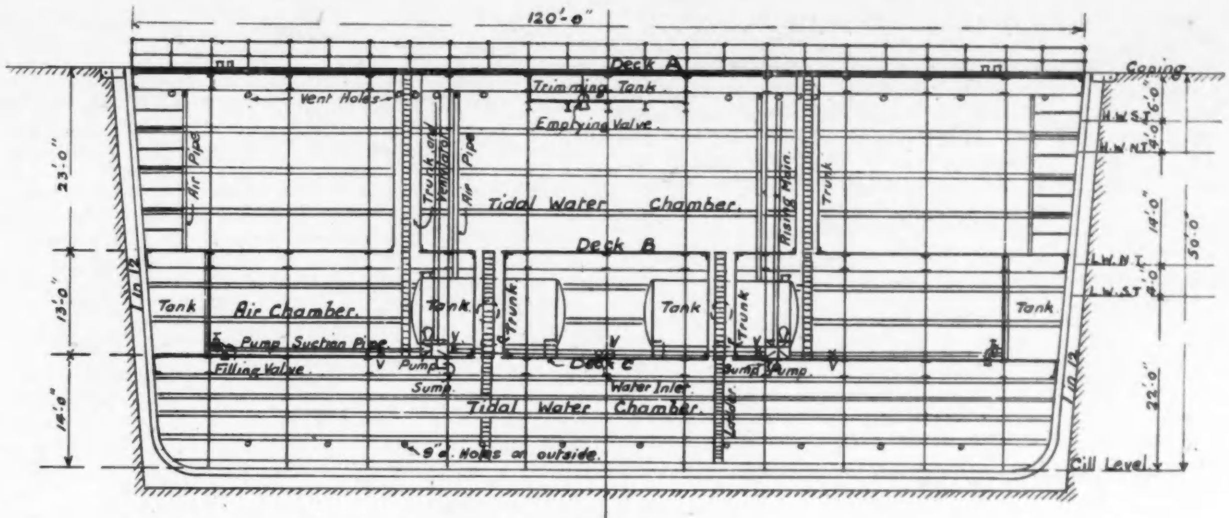


Fig.1.

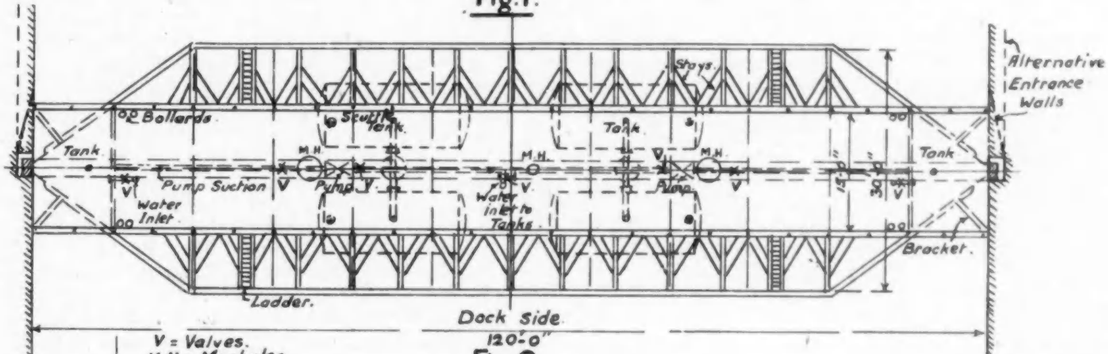


Fig.2.

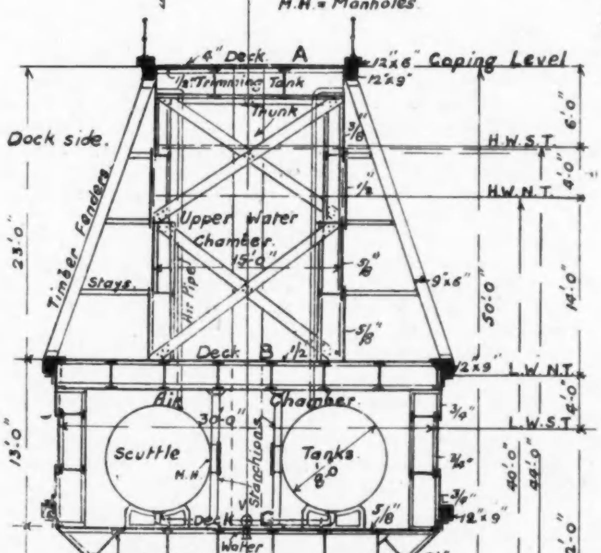


Fig.3.

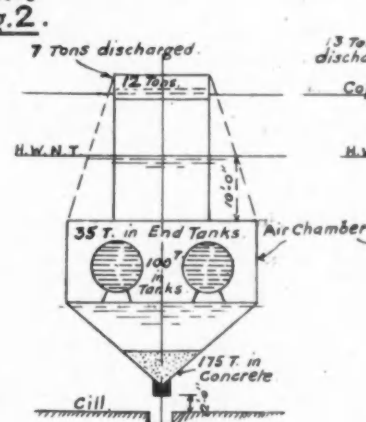


Fig.5.

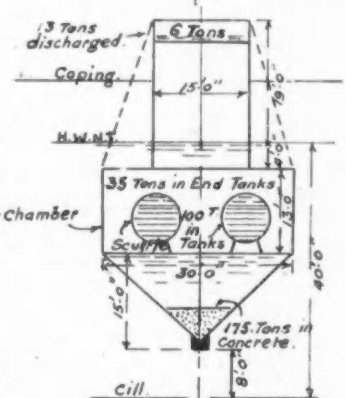


Fig.4.

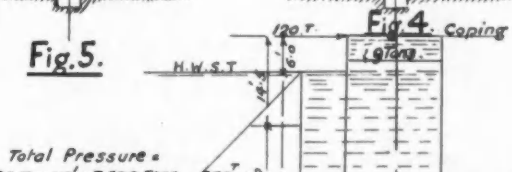


Fig.6.

Ship Caissons for Dock Entrances—continued

air chamber, and in order to do this, a certain amount of water must be retained in the water ballast tanks at the ends of the air chamber, the balance of the weight required to increase the draught of the caisson, being obtained by placing concrete or cast iron ballast in the bottom, to lower the centre of gravity, for the caisson without any ballast would float with a freeboard of about 3-ft. to the top of the air chamber.

When the caisson is about to be floated out of the entrance, the wedges at the top of the groove are removed, and the water in the trimming tank is discharged, and so much of the water in the scuttling tanks is either pumped or blown out, to cause the caisson to rise sufficiently to clear the entrance walls, having a batter of 1 in 12, a clear height of from 7 to 8-ft. between the keel and the dock cill will be required for this purpose.

To float out the caisson shown in Figs. 1, 2 and 3, with 1-ft. freeboard to the top of the air chamber, 175 tons of concrete ballast will be required in the bottom, and 35 tons of water ballast in the end tanks of the air chamber, while 100 tons of water in the scuttling tanks and 19 tons in the trimming tank will require to be discharged, but this will only be necessary for sea-going purposes.

The clearance between the keel and cill will be 13-ft. at H.W.O.N.T. (40-ft. of water) and 8-ft. for 35-ft. depth of water.

It may be floated out at H.W.O.N.T. with 8-ft. between the keel and cill, and the top deck of the air chamber 4-ft. below the water level, as shown in Fig. 4, by retaining 100 tons of water in the scuttling tanks and 6 tons in the trimming tank, and discharging 13 tons from the latter. The weight of the caisson will therefore be = 373 + 175 + 35 + 106 = 1,189 tons, which also will be the buoyancy. An extra 5 tons of water will be required in the trimming tank to provide against exceptionally high tides, this will also have to be discharged.

If the side walls of the entrance are vertical, then a rise of about 2-ft. between the keel and cill will be sufficient to float it out, as shown in Fig. 5, buoyancy will be about 1,119 tons, and with 100 tons of water in the scuttling tanks and 12 tons in the trimming tank, the weight of the caisson will be 1,119 tons, only 7 tons of water need be discharged from the top tanks. Ship caissons can be operated in entrances with vertical walls by either widening the outer portion of the entrance, or putting a splay in the walls as shown by the broken lines in the plan Fig. 2, in which case a rise of from 1 to 2-ft. between the keel and cill will only be necessary to clear. Special wedges operated by hand, hydraulic, or electric power will be required near the coping level to hold the caisson firmly against the entrance.

Pressures on Caisson and Entrance Walls

The diagram Fig. 6, shows the lateral pressures that the decks of the caisson will be required to sustain. The total pressure at H.W.O.S.T. for 45-ft. depth of water will amount to

$$\frac{45 \times 45}{2 \times 35} = 28.92 \text{ or say 29 tons per lineal ft. and 29 by 118-ft.}$$

= 3,422 tons, or 1,711 tons on each wall.

The maximum pressure at the cill level due to 44-ft. head of water = 1.25 ton by 112-ft. by 1-ft. = 140 tons or 70 tons per sq. ft. on each wall, and as the crushing strength of greenheart timber is about 5.8 tons per sq. in. or 835.2 tons per sq. ft., a safe load of 83.5 tons per sq. ft. on it is permissible. The granite quoin stones of the walls of the caisson groove, and those of the dock cill should be fine axed to a smooth and even surface, and the arrises rounded to a radius of $1\frac{1}{2}$-in. The caisson groove is 3-ft. 6-in. wide and 1-ft. 6-in. deep, a clearance of 4-in. is usually given between the width of the keel and that of the groove.

The friction of the caisson against the entrance walls with H.W.S.T. on the outside and no water in the dock will be as follows, viz.: the total lateral pressure is 3,422 tons, and the coefficient of friction for hard wood on stone is 0.38, therefore 3,422 $\times$ 0.38 = 1,300 tons pressure or upward force will be required to overcome the pressure against the walls, and as the buoyancy is 1,202 tons, with just sufficient ballast to sink the caisson, there will be a margin of 98 tons in friction to prevent the caisson rising.

(To be continued)

Legal Notes

Cargo-Handling: Alleged Breach of Dock Regulation

In a case heard at the Liverpool Court of Passage during March, a claim was brought by a Liverpool dock labourer, S. R. Ashworth, against Messrs. J. McGuirk & Co., a firm of master porters, for a breach of one of the Dock Regulations.

The circumstances are set out in the following judgment of the Presiding Judge (Sir W. F. Taylor, K.C.), as delivered on March 17th and reported in *Lloyd's List* of the following day:—

The **Presiding Judge** said the claim was for breach of Regulation 43 of the Dock Regulations, 1934, by which the duty was imposed, when cargo was being loaded or unloaded by a fall at a hatchway, that a signaller should be employed. On November 30th, 1941, the plaintiff was engaged in the work of unloading sacks of rice from the motor ship *Danmark* by receiving them from a sling on a stool or platform on the quay in Queen's Dock, Liverpool. While he was handling a sack to the truckman and had his back to the ship, Ashworth was struck on his back by a sling which had been lifted from the deck and hatchway of the ship and lowered on to the stool or platform on which the plaintiff was. Ashworth received serious injuries. It was agreed by the witnesses on both sides that no fresh sling should be conveyed from the ship and lowered on to the stool until the stool was cleared of the sacks from the preceding sling. That was necessary for the safety of the workman on the stool, whose attention was engaged in taking the sacks from the sling and disposing of them for trucking, and could not therefore be on the look-out for on-coming slings from the ship.

It seemed essential that there should be some person on board the ship to watch the stool and to see that it was clear of sacks before a fresh sling was lowered on to it. His Lordship understood that regulation 43 was made for that purpose and as a result of an agreement between masters and the men and their union, and it was clear from the evidence of both sides that there should be a man, termed by the witnesses "a railman," whose duty was to attach the sling to the hook on the chain from the crane, to watch that the stool was clear and then to signal to the craneman to hoist the sling, swing it over and lower to the stool. His Lordship found that such a signal was necessary because the craneman could not see the condition of things on the stool. The question fo rhis decision was whether, during the process when the cargo was being unloaded by a fall at a hatchway, a signaller was employed by the **defendants.**

The plaintiff had stated that a man remained at the rail until 1.30 p.m., and was then away for three-quarters-of-an-hour. He made a protest and shouted to the deck and people there, but got no reply. O'Brien, foreman of the shore gang, called by the defendants, said the railman was at the rail on his job at the time of the accident and that he spoke to the railman just before the sling came over.

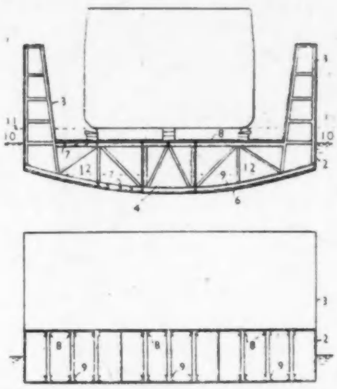
"I am not satisfied that the railman or a deputy was present when the sling in question came over, but on consideration of the evidence I find that the defendants did on this day and for the purposes of the process employ a man or men whose duty was to signal to the craneman to hoist the slings, and I am not prepared to hold that the defendants committed a breach of Regulation 43," declared his Lordship. "I am also satisfied that before any work began, the ship and shore gang were complete in number. No contention was raised by Counsel for the plaintiff as to whether the railman, who had work to do in connection with the sacks as well as to watch and to signal, could properly be regarded as a signaller within the meaning of the regulation. I think, therefore, the defendants succeed."

Judgment was given for the defendants, with costs.

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this Journal should not be taken as an indication that they are necessarily available for export

Design for New Type of Floating Dock

The following particulars of a design for a floating dock of a new type, in that the underside of the dock is curved instead of flat, is extracted from a recent issue of *The Motor Ship*. The design is the subject of an American patent (No. 550989), by Mr. F. R. Harris, of New York.



The dock comprises a pontoon (2) supporting side walls (3) having an air chamber (4). The pontoon of the dock has an arcuate or sloping bottom and a longitudinal airtight buoyant chamber. The weight of water displaced by the chamber is slightly less than the weight of the non-buoyant dry dock structure itself when under water, thus providing a small margin, sufficient for submerging the dock. The pontoon section, having a bottom (6) as shown in the diagram, allows of cut-away corners, thereby reducing the bending moments encountered as the ship is raised to clear the water, while the central buoyancy chamber reduces the combined stresses when the wings are first pumped out.

The outside shell plating is supported by the channel stringers (7), a few of which are shown. These in turn are supported by the top and bottom chambers (8, 9) and by interior bracing connecting transversely spaced points in the pontoon. The water pressure is transmitted with a resultant arch compression to the members (9) and the pontoon structure. When the dock is in its fully raised position, the water level (10) outside is just below the level of the deck.

When the ship is clear of the water and the outside level is that indicated (11), the water in the pontoon is at the level shown by the dotted line (12).

Port Facilities for Aircraft

Conference of Scottish Harbour and other Authorities

A sub-committee appointed by the Clyde Navigation Trust met in Glasgow on 25th March, Mr. William Cuthbert, Chairman of the Trust, presiding. Present at the meeting were representatives of several West of Scotland Local and other Authorities.

In his opening remarks, Mr. Cuthbert said the Prime Minister, in his most recent speech, had made it clear, and he thought all would agree. that although our first and paramount interest must be the winning of the war, arrangements and investigations ought to proceed so that we may be able to tackle the more important post-war problems as and when they emerge. He was aware that other Public Authorities had been giving consideration in recent years to the effect of developments in aviation, but the experience gained in the war made it obvious that whenever hostilities ceased there would be a tremendous advance in peace-time flying for commercial and pleasure purposes. He thought it was of urgent importance that the unique advantages which the West of Scotland afforded for an international aerodrome and possibly subsidiary aerodromes, should be impressed on the Government and we should now give full consideration to the part which the West of Scotland must play in any such development.

Mr. Cuthbert said that the Clyde Trust in common with other Harbour Authorities provided dock facilities for the arrival and departure of ships serving the trade of the world and that on the Clyde ships were built, repaired and served in every way. It seemed logical that the Clyde Trustees should consider the subject of world transport by air and the provision of aerodrome and service facilities irrespective of whether such facilities could be provided within the boundaries of the undertaking of the Clyde Navigation Trust.

The object of the meeting was to reach an agreed general policy and a full discussion took place after which all those representatives who had the requisite authority approved a motion by Mr. J. Wilson Paterson, seconded by Sir Henry Keith that there should be an International Air Port in Scotland and that a further meeting be called as soon as possible to consider a report to be prepared dealing with existing aircraft facilities and the arrangements, if any, already made or contemplated towards the provision of facilities for commercial aircraft.

Port of London Authority Board

Election of Chairman and Vice-Chairman and filling of Vacancies

The Port of London Authority have re-elected the Rt. Hon. Thomas Wiles, P.C., and Mr. Louis Hamilton Bolton, Chairman and Vice-Chairman respectively for the three years to 1st April, 1946. Mr. Wiles has been Chairman since 1941 and was Vice-Chairman from 1934-1941. Mr. Bolton has been Vice-Chairman since 1941.

The normal elections having been suspended on account of the war, an Order in Council has been promulgated extending for a period of three years—to 1st April, 1946—the term of office of the Elected Members of the Port of London Authority. These represent the shipowners, merchants, wharfingers and owners of river craft in the Port of London. The following will therefore continue to represent these interests:—Captain Sir Ian Hamilton Benn, Bart, C.B., D.S.O., T.D., Louis Hamilton Bolton, William Joseph Clarke, Sir Arthur Cory Cory-Wright, Bart., J.P., Colonel Arthur Charles Davis, D.L., J.P., Ronald Thornbury Garrett, Archibald Knightley Graham, Cecil Wilfred Hodge, Robert Kelso, Edward Aubrey Lloyd, H. Eric Miller, Owen Hugh Smith, Walter Harry Warwick, Percy Wharton, Rt. Hon. Thomas Wiles, P.C., William Lee Wrightson, O.B.E.

To fill vacancies due to resignations the following have been co-opted for the ensuing three years, viz.:—C. E. Alexander (Messrs. Capper, Alexander & Co.), W. E. Kelville (Messrs. Shaw, Savill & Albion Co., Ltd.).

The position of the Appointed Members of the Authority is different and the Government Departments and Public Bodies concerned have appointed the under-mentioned to represent them for the ensuing three years, viz.:—Vice-Admiral Sir John Edgell, K.B.E., C.B., F.R.S. (Admiralty); J. T. Scoulding, J.P., J. P. Blake, J.P. (Ministry of War Transport); Sir Alfred Baker, D.L., J.P.; Sir Bertram Galer, D.L., J.P.; Admiral Sir Alan Hotham, K.C.M.G., C.B.; D. W. Large (London County Council); Archibald Galloway, J.P.; Rt. Hon. Lord Rochester, C.M.G. (Corporation of the City of London); Captain A. H. Ryley (Corporation of Trinity House).

Retirement of Port Treasurer.

After 50 years' service with the Mersey Docks and Harbour Board, Mr. R. J. Wallace has retired from the post of treasurer, which he has held since 1932. Mr. Wallace, who is a native of Wigtonshire, entered the service of the Board as a junior immediately after leaving school, and gradually rose to the leading executive position which he ultimately occupied. He was well known in port circles and was chairman of the Port Collectors' Conference, taking part on behalf of the Dock and Harbour Authorities' Association in important negotiations affecting all the ports of the country. He is succeeded in his post as treasurer to the Mersey Docks Board by Mr. W. E. Moseley, hitherto assistant treasurer.